# Chapter 10

# FLYING CONTROLS

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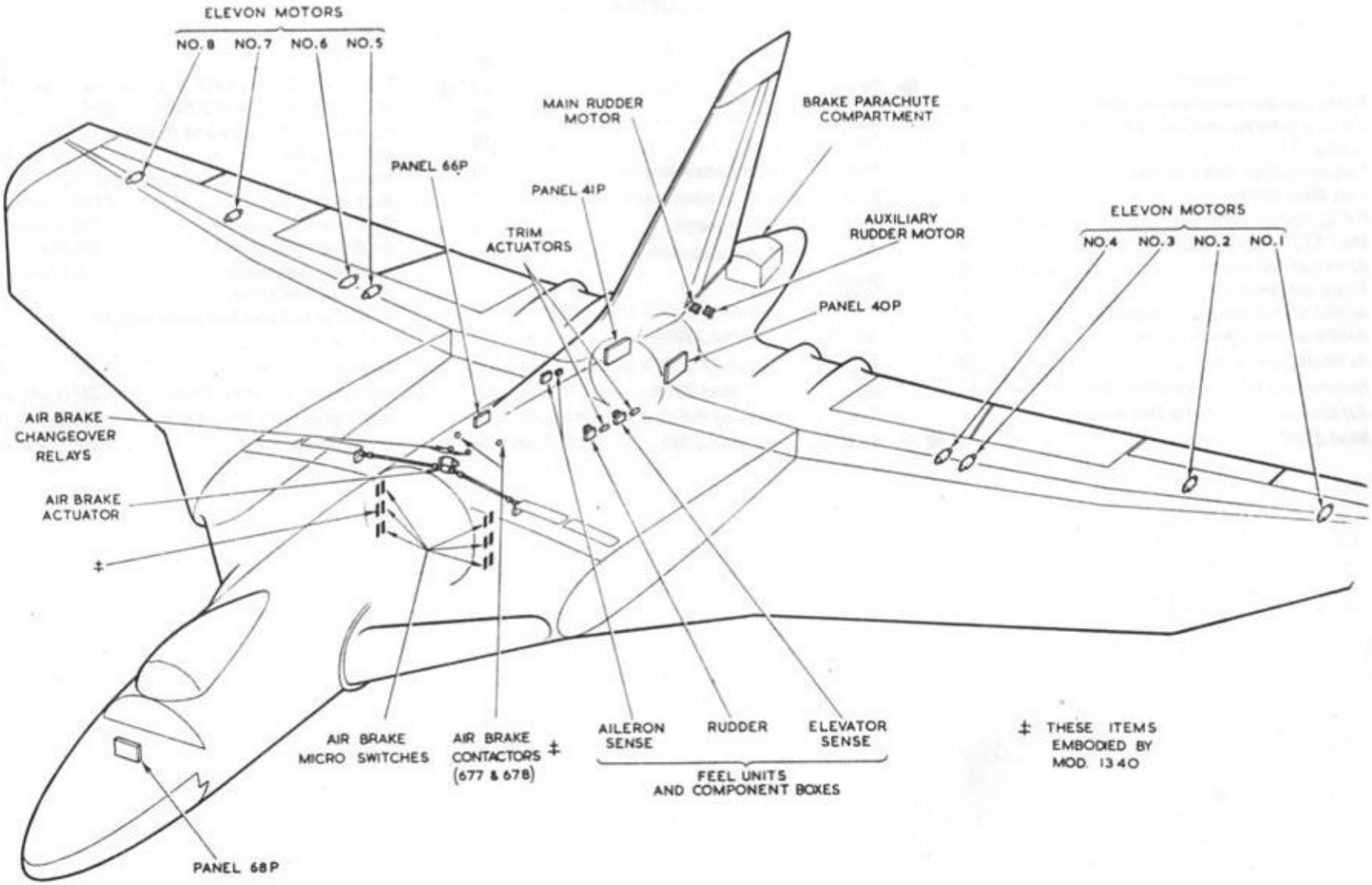



**Fig. 1 Location of components**

**Introduction**

1. This chapter contains descriptive and servicing information on the electrical controls and equipment for the powered flying control systems. These systems are as follows:-

(1) Powered flying controls.

(2) Artificial feel.

(3) Normal and emergency trim.

(4) Air brakes.

(5) Brake parachute.

2. Illustrations showing the location of equipment are provided, and theoretical circuit diagrams show the circuits in simplified form. The routing charts for the circuits are located at the end of the text. For information on the mechanical aspects of the systems, reference should be made to Sect.3, Chap.4 and 13. The following modifications, are incorporated:-

Mod.1045 - Load shedding of auxiliary rudder motor in lieu of H.F.

Mod.1311 - Introduction of P.F.C. motors, Type 1201/1 and 1203/1 in lieu of motors, Type 1201 and 1203.

Mod.1320 - Introduction of rapid engine start.

Mod.1340 - Improvements to the air brakes electrical circuit.

Mod.1383 - Introduction of contactors B.T.H., Type LDK.35/Y3/2 in lieu of contactors. Type LDK.35/Y1/1 in air brakes circuit.

Mod.1552 - Redistribution of loads on main alternators.

Mod.1806 - Introduction of microswitch as 2nd limit switch for aileron artificial feel actuator.

Mod.1856 - Autopilot, Mk.10B. To introduce improvements to permit full autoland operation.

Mod.1928 - Introduction of locking circuit for artificial feel and feel relief actuators.

Mod.2075 - Introduction of artificial feel units 26/R.4188 (aileron), 18/R.4349 (rudder), 29/R.4350 (elevator post Mod.1856) and 30/R.4350 (elevator pre.Mod. 1856) in lieu of 25/R.4188, 17/R.4349, 27/R.4350 and 28/R.4350.

Mod.2206 - Introduction of 2.5k ohm sensitivity potentiometer, Part No.CLR.1232/268 in lieu of 1k ohm potentiometer Part No. Z271601.

Mod.2263 - To remove autoland leader cable and auto-throttle facility from aircraft fitted with autopilot Mk.10B.

Mod.2316 - Introduction of an additional air brake motor isolation switch.

Mod.2352 - Introduction of a relay and diodes to prevent spurious indication of the air brake system.

Mod.2375 - A.R.I.5959 to make provision for and introduce an additional re-set switch at the second pilots' position.

Mod.2409 - To introduce Mk.10B autopilot equipment on aircraft not having Mod.360 embodied.

Mod.2398 - To introduce Type LP224 power factor correction units in lieu of Rotax Type ZA7801 capacitor.

▶ Mod.2451 - Introduces modified T.D.U.'s Type 30V/9303 and 34V/9303 to airbrake control circuit and Type 33/V9303 to elevator artificial feel circuit.

Mod.2467 - Introduces a diode into the air-brake indication circuit to prevent a voltage feed between the port and starboard busbars on failure of the starboard non-essential supply contactor. ◀

## POWERED FLYING CONTROLS

3. Due to the heavy aerodynamic loading on the flying control surfaces a considerable physical effort would be required to move them in order to effect control of the aircraft in flight. For this reason a system is provided whereby the control surfaces are moved by means of hydraulic pressure, which is obtained from pumps driven by electric motors.

## DESCRIPTION AND OPERATION

Movement of the pilots' controls operates a system of valves, which in turn direct the pressure to move the control surfaces as required.

4. When Mod.1320 is embodied (Chap.8, App.1), provision is made to start the powered flying control (.P.F.C.) circuits simultaneously with the aircraft engines. The appropriate paragraphs refer.

**Control surfaces**

5. The conventional ailerons and elevators are combined to form a system of control surfaces referred to as elevons. These are split into eight independently powered surfaces and fitted four to the trailing edge of each wing. The system thus provides continuing powered control of the aircraft in the event of failure affecting any of the pump units. The surfaces are numbered 1 to 8 from the port side and their arrangement, together with the associated power units, is shown at fig.1.

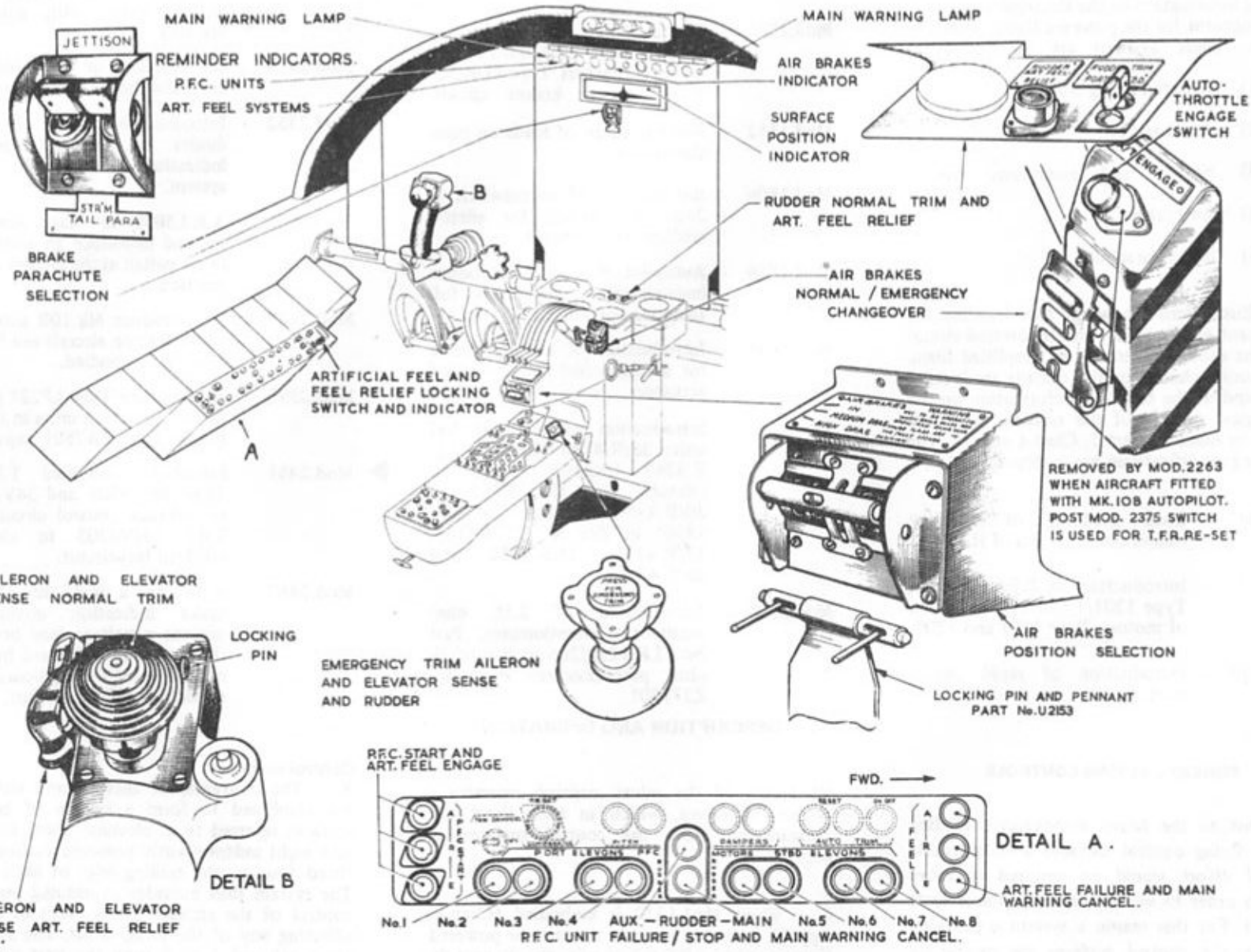



Fig.2 Pilot's control switches and indicators

6. Operation of the pilots' controls to effect climb or descent will cause all eight surfaces to move up or down in unison. Operation of the pilots' controls to effect bank will cause movement of the four port surfaces in unison, but in opposition to the movement, also in unison, of the four starboard surfaces.

7. A single surface is provided to effect rudder control, duplication of control in this case being afforded by two independent pump units. Normally, both units are running concurrently, but should the main unit fail, either electrically or hydraulically, the auxiliary unit will automatically take over the rudder control surface operation.

**Autopilot control**

8. Under autopilot control, movement of the flying control rods is effected by servo motors located in the bomb bay and power compartment. The autopilot (Mk.10A or 10B) is described in Sect.7, Chap.6.

**Control switches**

9. The switches provided to start and stop the P.F.C. units are located on a panel attached to the port console 6P. Three douple-pole push-switches Ref.No. 5CW/5057 are mounted across the aft end of the panel. They are labelled P.F.C. START and designated A-R-E. One half of each switch controls the starting via a time delay switch, of a group of P.F.C. units in the following automatic sequences:-

A - elevon units, No.1, 2, 7 and 8
E - elevon units, No.3, 4, 5 and 6
R - rudder units, main and auxiliary

These switches may be operated simultaneously only when all four aircraft alternators are on line. Under any other conditions they should be operated in rotation allowing each group start to be completed before selecting the succeeding group.

10. The other half of each switch engages the artificial feel system corresponding to its designation i.e.:-

A - aileron sense control
E - elevator sense control
R - rudder control

11. Ten illuminated, spring return push-switches, Page Type C.750C5, are mounted along the inboard edge of the panel and are labelled P.F.C. MOTORS. They are grouped in pairs and arranged in plan to represent the relative position on the aircraft of their respective P.F.C. units. The switches are additionally designated PORT ELEVONS – RUDDER – STBD. ELEVONS and besides controlling the stop circuit of their respective motor, house the failure warning lamp of that unit. Reading from the aft end, the switches for the port elevons control the No.1, 2, 3 and 4 units whilst those for the starboard elevons control the No.5, 6, 7 and 8 units. The outboard of the two rudder switches controls the port or auxiliary unit whilst the inboard controls the starboard or main unit.

**Time delay switches**

12. Three time delay switches, Rotax Type D8187, are employed to effect automatic sequential starting of the P.F.C. units in accordance with para.9. Those for the A and R circuits are fitted to panel 40P and that for E to panel 41P (fig.3). Briefly, the time delay switches connect supplies to close the heavy duty contactors of their respective P.F.C. units in succession. Each supply is connected for 3 seconds then a 1 second interval occurs before connection of the supply to the succeeding contactor. Full technical details of the time delay switches are contained in ◀A.P.115D-1412-16.▶

**P.F.C. units**

13. Ten electro-hydraulic powered flying control units are fitted, these consist of:-

| | |
|---|---|
| No.1 elevon<br>No.2 elevon<br>No.7 elevon<br>No.8 elevon | Boulton Paul<br>Type P.135 |
| No.3 elevon<br>No.5 elevon | Boulton Paul<br>Type P.132 (right hand) |
| No.4 elevon<br>No.6 elevon | Boulton Paul<br>Type P.132 (left hand) |
| Rudder main<br>Rudder auxiliary | Boulton Paul<br>Type P.138 |

14. Similar units are interchangeable. The difference between the Type P.132 left and right hand units is necessary for installation purposes. Descriptive details for the pump units will be found in the following A.P.'s:-

◀ Type 135 . . . . A.P.105D-1901-16A
Type 132 . . . . A.P.105D-1902-16A
Type 138 . . . . A.P.105D-0305-16 ▶

15. Each unit is driven by a 200-volt 3-phase a.c. motor controlled from the 28-volt d.c. system. The motors are integral parts of the P.F.C. units and the types employed are as follows:-

| | |
|---|---|
| P.F.C. unit Type P.132 | Rotax motor |
| P.F.C. unit Type P.135 | Type CA1201 |

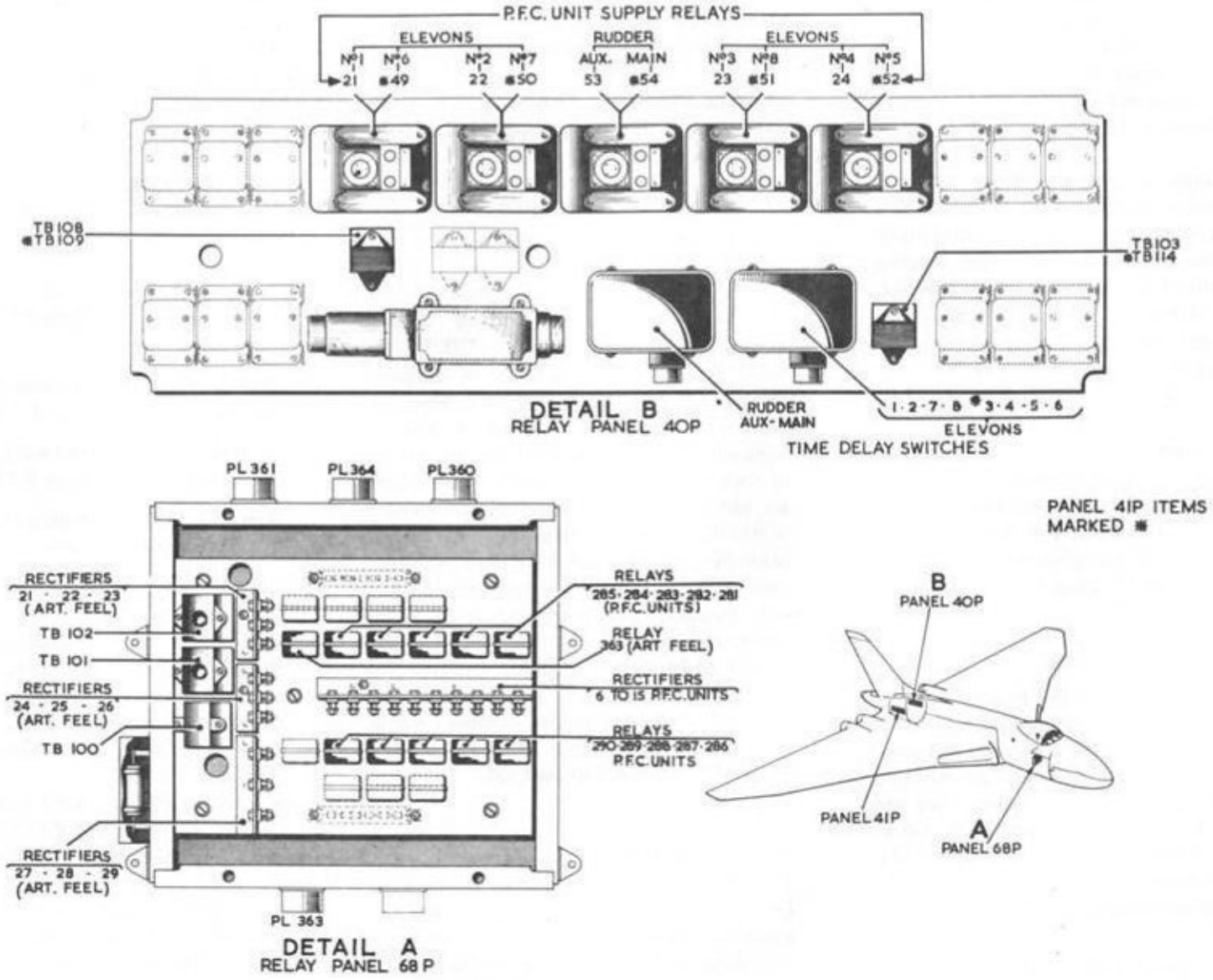



Fig. 3 P.F.C. contactor and indicator relay panels

P.F.C. unit Type P.138 — Motor Type CA1203

*NOTE . . .*
*When Mod.1311 is embodied these motors are replaced by Type CA1201/1 and CA1203/1 respectively.*

Descriptive details for the motors will be found in A.P.113E-0364-1 and A.P.113E-0365-1.

**Main warning system**

16. A main warning system, consisting of two amber indicator lamps, Page Type C.331C, is employed. The lamps are fitted, one at each end of the indicator array at the top of the pilot's centre panel, and are labelled MAIN WARNING. Supplies to light the lamps will be fed in the event of failure occurring in the following systems:-

(1) P.F.C. units.

(2) Artificial feel.

(3) Autostabilization.

**Indicators**

17. A control surface position indicator is installed on the pilot's centre instrument panel. The ten warning lamps housed in the stop switches will light to give an amber display indicating that their respective unit is either stopped or subject to a pressure failure. A magnetic indicator, Type B2, is mounted adjacent to the 1st pilots' main warning lamp and is labelled P.F.C. UNITS. This indicator is energized to give a black display whilst normal working conditions prevail. It will be de-energized to give a white display on the operation of any of the stop switches to isolate the defective unit in the event of a failure. The operation of the central and individual failure warning indicators and circuits is described fully in para.28 to 41.

**Panel 68P**

18. This panel is installed under the floor at the pilot's position on the starboard side of the aircraft (fig.3). It contains the relays and rectifiers for the indicator circuits of the P.F.C. artificial feel and autostabilization systems. A resistor, fitted externally on the panel, functions in the reminder indicator circuit of the autostabilization system.

**Supplies**

19. Heavy duty supplies for the P.F.C. motors are obtained from the 200-volt, 3-phase, 400 Hz a.c. system via fuses in panels 58P, 59P, 60P and 61P. The heavy duty contactors are fitted to panels 40P and 41P (fig.3). Details of fuse numbering will be found in Chap.3. The control circuits and indicators are fed from the 28-volt d.c. system via fuses in panels 3P, 4P and 26P. The indicator relays are fitted to panel 68P, and details of fuse numbering will be found in Chap.6. The starting circuits for the motors will become operative when both 28-volt d.c. and 200-volt a.c. supplies are made available. Relay types, together with their numbers and functions, are given in Table 1. Descriptive and servicing information for the relays will be found in A.P.105D-1901-16A.

*Power factor correction*

20. Two capacitor boxes, Type ZA7801, are included in the supply circuit of each motor to provide power factor correction. In the case of elevon motors No.1, 2, 7 and 8, these are installed at the respective port or starboard outer wing break. In the case of elevon motors 3, 4, 5 and 6 and the two rudder motors, they are installed adjacent to their respective motors. The boxes contain the capacitors and fuses of the correction circuits, which consist of three parallel banks of four 1 micro-farad capacitors. The capacitors are separately fused, and the banks are connected one between each of the supply phases. The boxes are sealed units and a label on each box carries the following instruction:-

**"IMPORTANT"**
**"Do not short circuit this condenser; discharge through resistance of not less than 5 000 ohms."**

◀ When Mod.2398 is embodied, the two capacitor boxes are replaced by one Type LP224 power factor correction unit. ▶

**Circuit operation**

21. As the starting circuits for all three groups detailed in para.9 are similar, only that for elevons 1, 2, 7 and 8 is described in the following paragraphs. It should be noted that in the case of the circuit for the rudder units shown at fig.5, only two contacts of the time delay switch are employed.

*Starting elevon units 1, 2, 7 and 8*

22. Referring to fig.4, it will be seen that when 28-volt d.c. and 200-volt a.c. supplies are connected to the aircraft systems, the unit warning lamps and the main warning lamps will be lit by supplies fed via the failure warning circuit. Depressing the group start switch will connect a supply from fuse 601 via terminals 1-2 to pole M of the time delay switch, resulting in the following circuit action:-

(1) Operation of the time delay switch will close its No.1 contacts, connecting a supply from fuse 478, via poles B and C of the switch to energize the close coil of the No.1 elevon engage relay No.21.

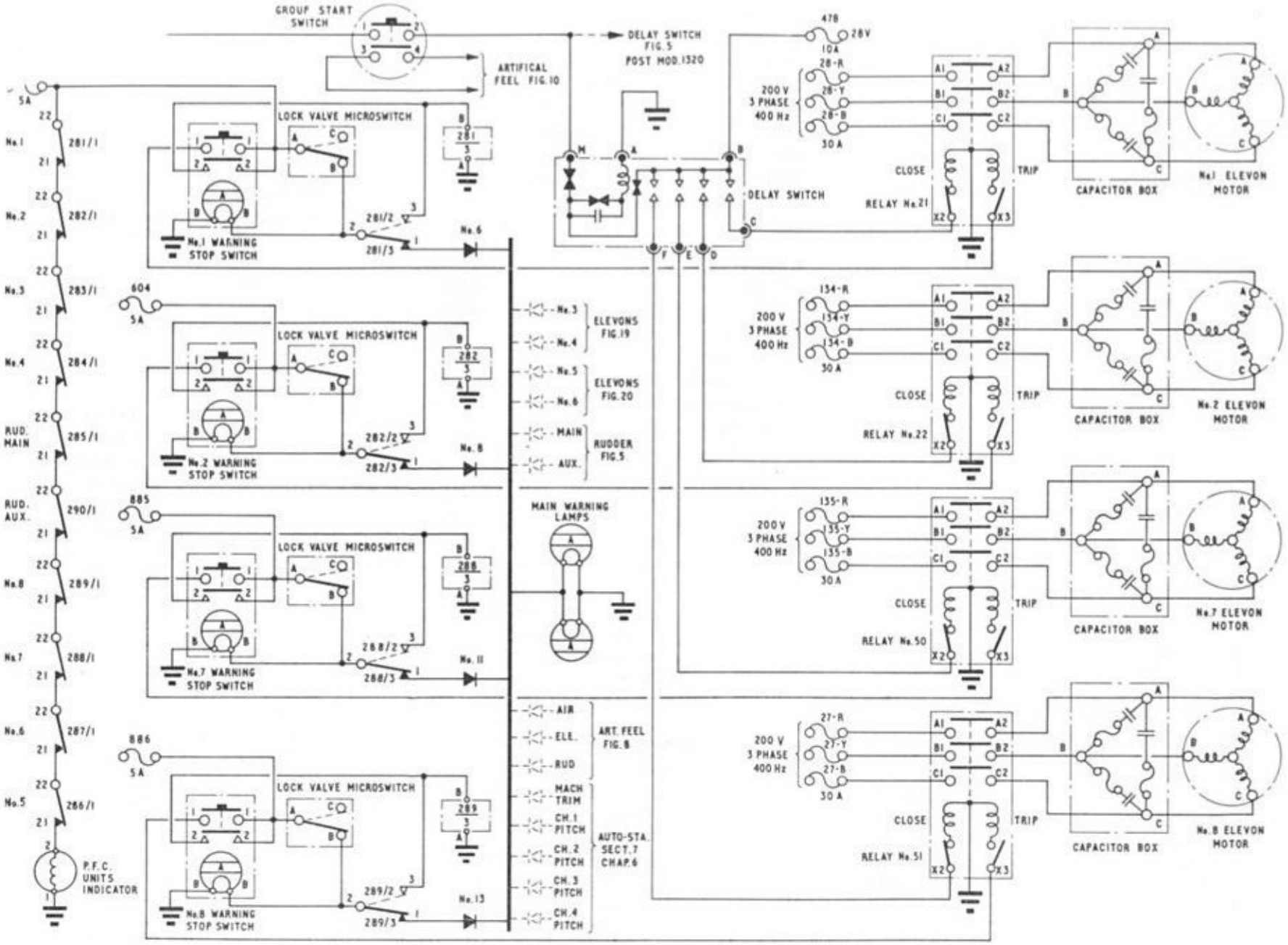



Fig. 4 Elevon control (pre and post Mod. 1320, post Mod. 2263)

◀ Mod state clarified ▶

(2) Relay No.21 contacts A1-A2, B1-B2 and C1-C2 close connecting a 200-volt a.c. supply from fuses 28R, Y and B, to the motor of the unit, which will commence to run.

(3) The continued operation of the time delay switch at (1) will connect a supply from fuse 478 via its No.2, 3 and 4 contacts in succession, to start the No.2, 7 and 8 units respectively, via the associated engage relays and supply fuses.

(4) As the pressure in each unit develops, the individual warning lamp will be extinguished. The main warning lamps will remain lit until all the associated systems are engaged.

*Stopping individual P.F.C. units*

23. As the stop circuits of the ten P.F.C. units are identical, the following operation, which is given for the No.1 elevon unit, applies in each case, taking into consideration the appropriate fuses and control switches (fig.4). Under normal conditions, momentary depression of the No.1 elevon unit stop switch will cause the following circuit action to take place:-

(1) A 28-volt d.c. supply is fed from fuse 603 via contacts 1-1 of the No.1 stop switch to energize the trip coil of the engage relay No.21.

(2) Relay No.21, contacts A1-A2, B1-B2 and C1-C2 will open, disconnecting the supplies from fuses 28R, Y and B to the No.1 elevon unit motor which will stop.

(3) As the pressure falls the individual warning lamp and the main warning lamps will light.

24. It should be noted that the momentary depression of the stop switch at para.23 will, also connect a supply from fuse 603 via terminals 2-2 of the No.1 stop switch to energize warning relay No.281. This will cause a momentary lighting of the stop switch lamp and blink of the reminder indicator.

*Stopping on failure*

25. On receipt of a failure indication, depression of the appropriate stop switch will cause circuit action as at para.23(1) and (2) in respect of the failed P.F.C. unit. If for any reason the incorrect stop switch is depressed, resulting in the stoppage of a P.F.C. unit not subject to failure, it can be re-started by operation of the respective group start switch. Such operation will cause the time delay switch to function through its starting cycle and operation of the correct stop switch will then stop the requisite motor.

*Switching off after use*

26. As the engage relays in the starting circuits of the P.F.C. units are of the latched type they will remain in the engaged position until the respective stop switch has been depressed. It is essential therefore that after flight or ground test use the stopping of all the P.F.C. units is effected by correct operation of the stop switches. This applies also after ground servicing of the artificial feel units which are controlled by the P.F.C. start switches. This action is necessary to prevent damage or injury, resulting from the simultaneous starting of any of the P.F.C. units, which would otherwise occur automatically if a 200-volt a.c. supply was subsequently connected to the aircraft system, particularly during servicing operations.

*Mod.1320*

27. With Mod.1320 embodied, the elevon and rudder P.F.C. units will be started up at the same time as rapid starting of the aircraft engines. When the appropriate control switches for rapid starting are selected, and the rapid start push-switch is pressed (Chap.8, App.1), a supply from fuse 674 will be fed via contacts 3 - 4 of the push-switch to energize the rudder P.F.C. time delay unit via pole M (fig.5). This in turn will energize the elevons P.F.C. time delay units so that all P.F.C. motors will immediately be started up, thus eliminating the normal starting sequences. (See also para.97).

**Failure warning system**

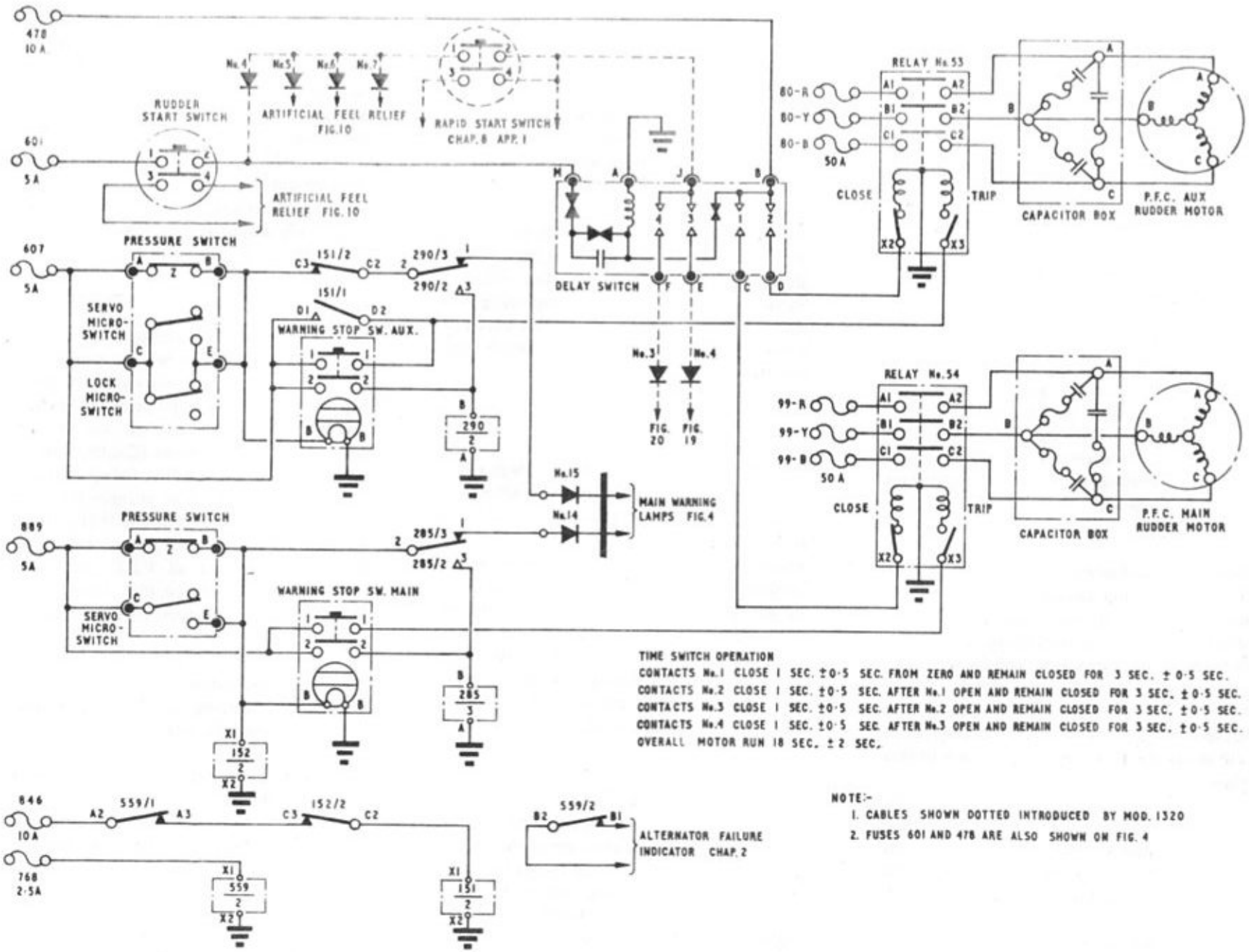
28. Failure warning for the P.F.C. units is provided by the following:-

(1) A control surface position indicator.

(2) Individual unit failure and stop lamp.

(3) Main warning lamps.

(4) Reminder indicator.




TIME SWITCH OPERATION

CONTACTS No.1 CLOSE 1 SEC. ±0·5 SEC. FROM ZERO AND REMAIN CLOSED FOR 3 SEC. ± 0·5 SEC.
CONTACTS No.2 CLOSE 1 SEC. ±0·5 SEC. AFTER No.1 OPEN AND REMAIN CLOSED FOR 3 SEC. ± 0·5 SEC.
CONTACTS No.3 CLOSE 1 SEC. ±0·5 SEC. AFTER No.2 OPEN AND REMAIN CLOSED FOR 3 SEC. ± 0·5 SEC.
CONTACTS No.4 CLOSE 1 SEC. ±0·5 SEC. AFTER No.3 OPEN AND REMAIN CLOSED FOR 3 SEC. ± 0·5 SEC.
OVERALL MOTOR RUN 18 SEC. ± 2 SEC.

NOTE:-

1. CABLES SHOWN DOTTED INTRODUCED BY MOD. 1320
2. FUSES 601 AND 478 ARE ALSO SHOWN ON FIG. 4

Fig. 5 P.F.C. Rudder control circuit ( pre and post Mod 1320, post Mod. 2263 )

◄ Mod state clarified ►

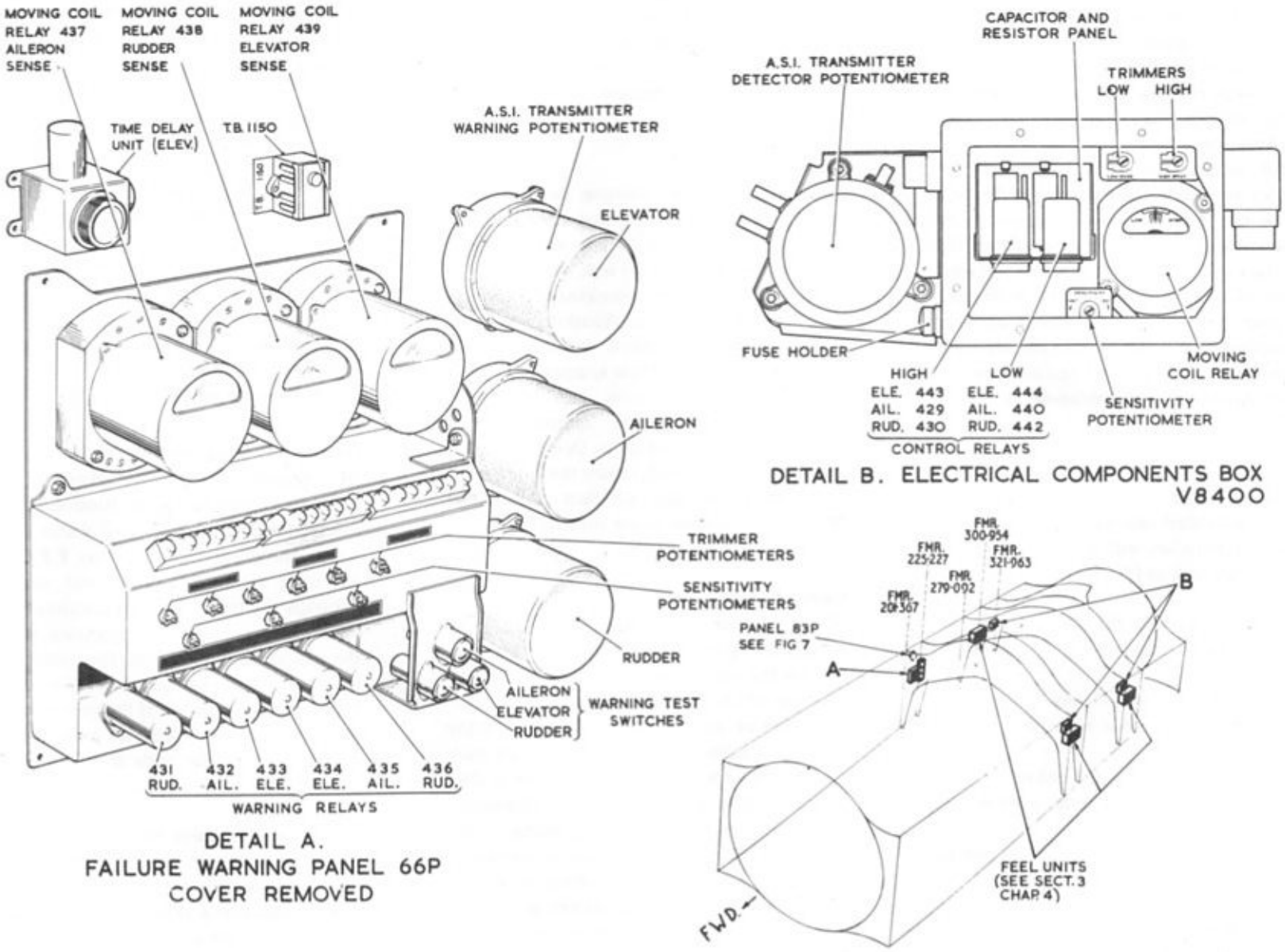



Fig. 6 Artificial feel components

*Control surface position indicator*

29. An indicator on the pilot's centre instrument panel shows the position of all the control surfaces simultaneously. It enables the pilots to check that the controls are operating correctly and in the right direction. Two datum lines, one vertical and one horizontal, are fixed on the face of the instrument and represent a view of the aircraft looking forward from the tail end. Indication is provided by nine fluorescent arms which move across the datum lines and simultate the control surfaces. The control of each indicator arm is effected by a position transmitter operated by each flying control surface. Descriptive and servicing information for the control surface position indicator installation is contained in Sect.7, Chap.2.

*Unit warning lamps*

30. The individual unit warning lamps fitted to the stop switches will indicate failure of their respective unit as follows:-

(1) On starting, the lamps will remain lit as a result of:-

(a) Failure of any of the lock valves due to seizure.

(b) Failure of either of the rudder pressure switches.

(c) Failure of the pump unit to develop pressure.

(2) Whilst the units are operating the lamps will light as a result of:-

(a) Loss of pressure due to failure in the supply, motor or pump unit.

(b) Additionally, in the case of the rudder units, failure of either servo valve due to seizure of its associated lever mechanism.

*Main warning lamps*

31. The two main warning lamps form a central warning system in that they will light to indicate the failure of any of the P.F.C. units and, in addition, to indicate a failure in either of the other two associated systems, i.e., artificial feel and autostabilization. The lamps will light under the initial circuit conditions caused by a failure in these systems and, in the case of the P.F.C. units, this will occur simultaneously with the lighting of the respective unit warning lamp. Operation of the appropriate stop switch causes the lamps to be extinguished and they are then available for the initial indication of any subsequent failure.

*Reminder indicator*

32. Under normal conditions this indicator is energized to give a black indication by a supply fed via the series connected, normally closed contacts of the warning relays for each unit. Operation of any of the stop switches in the event of a failure, causes the respective relay contacts to open and the indicator is then de-energized to show a white face. This occurs simultaneously with the extinguishing of the main warning lamps, and the circuit is arranged to cause the indicator to continue to show a white face when the stop switch is released. The indicator then functions as a reminder to the pilot that a failure has occurred.

*Warning relay*

33. The energizing supply to the coil of the warning relay is controlled by the respective stop switch. Operation of the stop switch in the event of a failure will cause change-over of the relay contacts to:-

(1) Extinguish the main warning lamps.

(2) De-energize the reminder indicator to show a white face.

(3) Connect a hold-in supply to the coil of the relay.

The hold-in supply causes the reminder indicator to continue showing a white face in accordance with para.32.

*Pressure and micro switches*

34. Supplies to the individual unit lamps and the main warning lamps, are controlled initially on failure by pressure and micro switches which are integral parts of the P.F.C. units. Referring to fig.4 and 5, will show that although the failure warning circuits of the ten P.F.C. units are similar in operation, those for the rudder units vary from the elevon circuits in the following respects. Whereas the lock-valve micro switch of the elevon units is in the released position with no pressure applied, that for the rudder units is in the depressed position.

35. The lock valve for the rudder control surface is common to the pressure of both units and for this reason, in order to cause failure indication if either should fail, each unit is provided with a separate pressure switch. Both rudder units are additionally provided with a micro switch fitted adjacent to, and mechanically operated by, the servo valve mechanism. Under normal conditions the contacts of both switches are open circuited,

but whereas the switch for the main unit is released, that for the auxiliary unit is depressed. Should either servo valve fail due to seizure of defect in its lever mechanism, the switch will be operated to close its contacts thus completing the failure warning circuit.

**Circuit operation**

36. Operation of any switch in the failure warning circuits will cause the same sequence of operations. The following description is given for the No.1 elevon units. This description also applies for the circuits of the other units, except for the supply to the reminder indicator.

37. Fuse 603 will feed 28-volt d.c. as follows:-

(1) Via the series connected and normally closed No.1 contacts of the warning relays of each unit 281/1, 282/1 etc., energizing the reminder indicator to show a black display.

◀ (2) Via contacts A and B of the lock valve microswitch (C and E in the rudder units) and via both pressure switches to light the stop lamps. ▶

*Starting*

38. When a 200-volt a.c. supply is connected to the aircraft system and the P.F.C. unit started, the resulting rise in pressure will cause operation of the lock valve microswitch. Opening of the switch contacts will extinguish the unit warning lamp and disconnect the supply in respect of this unit to the main warning lamps. Operation of the pressure switches in the case of the rudder units will cause the same result. Only when all the units have been started will all the individual stop switch lamps be extinguished. Although the respective supplies to the main warning lamps will also be disconnected these will continue to be lit until the other associated systems are correctly engaged.

*Failure*

39. Assuming that the three systems associated with the main warning lamps are correctly engaged, then should a failure of the motor, pump unit, or 200-volt a.c. supply occur, the following circuit action will take place:-

(1) The resulting fall in pressure will cause operation of the lock valve microswitch, connecting terminals A-B.

(2) A supply is fed from fuse 603 via terminals A-B of the lock switch to light the unit warning lamp and via the normally closed relay contacts ◀ 281/3 to light the main warning ▶ lamps.

In the case of the rudder units the fall in pressure will operate the respective pressure switch.

*Stopping*

40. In order to stop the failed unit, the stop switch should be depressed, resulting in the following circuit action:-

(1) A supply is fed from fuse 603 via terminals 1-1 of the switch to trip the engage contactor thus stopping the unit.

(2) The supply from fuse 603 via terminals 2-2 of the switch will also energize the coil of the warning relay 281.

(3) Opening of contacts 281/1 will break the supply from fuse 603 to the reminder indicator which will de-energize to show a white display.

(4) Opening of the normally closed ◀ contacts 281/3 will break the ▶ supply from fuse 603 to the main warning lamps.

◀ (5) Closing of contacts 281/2 will ▶ transfer the supply at (4) to form a hold-in supply to the coil of relay 281.

41. When the stop switch is released, the hold-in supply to relay 281 will cause the indicator to remain de-energized giving a white display, reminding the pilot that a failure has occurred. The unit warning lamp will remain lit confirming which unit has been stopped. Subsequent disconnection of the 28-volt d.c. supply from the aircraft system will remove the hold-in supply from relay 281. Rectification of the failure will then restore the failure warning circuit to its normal working conditions.

*Mod.1045*

42. With the embodiment of Mod.1045 provision is made to shed the auxiliary rudder motor during emergency conditions in flight (i.e. when the R.A.T. is lowered). Reference to fig.5 will show that under normal circuit conditions relay 559 will be energized from the 28-volt d.c. non-essential busbar via fuse 768. Consequently contacts 559/1 will be open.

43. If the R.A.T. is lowered, the supply to the non-essential busbar will be disconnected (Chap.6), and relay 559 will be de-energized. Contacts 559/1 will close to connect a supply from the essential busbar via fuse 846, contacts 559/1 and 152/2 to energize relay 151. Contacts 151/1 will close to trip relay 53 thus cutting off the supplies to the auxiliary motor, which will stop. At the same time, contacts 151/2 will open to cut off the supply from fuse 607 to the main warning lamps.

44. Provision has also been made so that if a fault occurs in the main motor circuit, the auxiliary motor will assume control of the rudder system and will not be isolated from its supply.

45. Should a fault develop in the main motor circuit, a supply will be connected from fuse 889 to energize relay 152. (fig.5). Contacts 152/1 and 152/2 will open to isolate relay 151 from the circuit. This action will prevent relay 151 from being energized, which in turn will prevent the auxiliary motor from being isolated.

### ARTIFICIAL FEEL

46. The artificial feel system has been designed to simulate aerodynamic loading at the pilot's flying controls. This is effected by three artificial feel units, one for each control axis, which provide and vary a restriction to the movement of the controls in their respective axes. In order to correlate the application of feel to the elevon control surface system for the purposes of this text, the following terms have been adopted:-

Aileron sense - Movement of controls to effect bank.

Elevator sense - Movement of controls to effect climb or descent.

47. Control of the system provides for the application of feel under the following conditions:-

(1) Feel engaged.

(a) In the case of the aileron sense unit, a restriction is applied which causes the angle to which the control surfaces can be moved to vary inversely with airspeed.

(b) In the case of the elevator sense and rudder units, a resistive force is applied which causes the freedom in movement of the controls to vary inversely with airspeed.

(2) Feel relief.

(a) In the case of the aileron sense unit, this condition permits full angle of the control surfaces to be applied.

(b) In the case of the elevator sense and rudder units, this provides for the reduction of the resistive force to a fixed minimum.

48. Adjustment of the units, according to airspeed variation in the feel engaged condition, or to the feel relief condition in the event of failure indication, is effected by electrically controlled actuators. The difference in operation between the aileron sense unit (restriction of angular movement) and the elevator sense and rudder units (resistance to movement) is provided by the respective mechanical systems.

49. Although the basic electrical circuit is common to all three systems the following variations should be noted. In the case of the elevator sense and rudder feel units two actuators are employed, one to adjust the mechanical system in accordance with airspeed variation and designated the feel actuator, the other to move the mechanical system from the engaged to the relief actuator. In the case of the aileron sense feel unit a single two motor actuator is employed to perform both functions, the respective motors being designated accordingly i.e., feel or relief. To conform with the different mechanical systems referred to at para.48, the feel actuators of the elevator sense and rudder units are caused to retract or extend respectively with increase or decrease in airspeed, whereas the actuator of the aileron sense unit is caused to extend or retract respectively with increase or decrease in airspeed.

50. The circuit arrangement is such that, if feel relief is not selected after normal use, disconnection and subsequent reconnection of supplies to the aircraft will cause the relief actuators or motor to automatically move their mechanisms to the relief condition. A very small movement only will result in the case of the aileron sense actuator. Operation of the elevator and rudder P.F.C. start switches will cause their respective relief actuators to move the systems to the feel engaged position. Operation of the aileron P.F.C. start switch will set the field circuits of the aileron sense unit feel motor in readiness for operation.

Movement of the actuator will not occur until airspeed is increased to exceed the cut-in speed for the system.

51. The electrical operation of the artificial feel system is dealt with in the following paragraphs which include a brief description of the mechanical system. The mechanical operation is fully described in Sect.3, Chap.4 of this publication.

52. In the case of the elevator sense and rudder units, the mechanism which provides the varying resistive force, consists of a spring loaded lever system. The spring tension is adjusted by means of a moveable fulcrum arm. Movement of the fulcrum arm, in accordance with airspeed variation, is effected by the feel actuator. The system is so arranged that at low airspeed, a large movement of the controls results in a small amount of spring compression. At high airspeed a small movement of the controls results in a large amount of spring compression. When feel relief is selected the relief actuator moves the fulcrum to a fixed position where the spring compression is of a small degree.

53. In the case of the aileron sense unit the mechanism which provides the restriction of the control surface angle consists of a folding lever system. Contraction and expansion of this system in relation to fixed stops and in accordance with airspeed variation is effected by the feel motor. When feel relief is selected the relief motor moves the system to the fully contracted position thus permitting full movement of the controls.

54. To obtain the necessary change in the mechanism setting with changes in airspeed, a control system is employed consisting of two potentiometers connected in parallel. One potentiometer is mounted adjacent to the components box. The wiper arm of this potentiometer is connected to a diaphragm which is operated from the starboard pitot-static system. Any changes in airspeed will cause the wiper arm to move around the potentiometer which is therefore referred to as the detector potentiometer. The other potentiometer is mounted inside the feel unit and its wiper arm is connected to and moved relative to the mechanism. This potentiometer is referred to as the follow-up potentiometer.

55. The wiper arms of the two potentiometers are interconnected through the coil of a sensitive moving coil relay, the coil being energized whenever the wiper arms are at different potentials (i.e., out of balance). Movement of the contact arm of the moving coil relay to left or right will complete the coil circuits of one of two relays. The contacts of these relays control supplies to either the extend or retract field of the feel actuator, which will thus be operated to cause a change in the mechanism settings relative to variation in airspeed. The wiper arm of the follow-up potentiometer will be moved relative to the mechanism until a new position of equal potential is obtained between the potentiometers. When this occurs, the moving coil relay will be de-energized and centring of the contact arm will in turn de-energize the coil of the field relay. The supply to the extend or retract field will be disconnected and the actuator will stop at the re-adjusted setting of the mechanism.

56. A warning potentiometer, operated by the port pitot-static system, is connected in parallel with the control circuit. The moving coil relay of the warning circuit is connected between the follow-up potentiometer wiper arm and the warning potentiometer wiper arm. The circuit is arranged so that any electrical failure of the artificial feel control system, or out-of-balance due to 'runaway' of the actuator, will set up an out-of-balance condition between the control circuit and the warning circuit. This action will cause the moving coil relay contacts to operate, and via control relays, operate the failure warning indicator on the pilot's panel.

**Feel and feel relief locking**

57. The introduction of Mod.1928 enables all artificial feel and feel relief actuators to be locked in any predetermined position by manual selection. This facility is used to prevent the possibility of actuator runaway to a low speed value when the aircraft is flying at high air speed and low altitude.

58. The locking circuit is controlled by a 2-position switch, labelled NORMAL-LOCK, located on a bracket attached to the port console (fig.2). Control of the actuators is maintained by interrupting the earth returns via the contacts of relays 798 and 799, which are energized when the switch is selected to LOCK. Indication of locking is given by a press-to-test indicator, Page Type C500B7, fitted adjacent to the switch.

**Autopilot control**

59. The autopilot (Mk.10A or 10B) exerts a limited amount of control over the aileron and elevator feel circuits. With the autopilot engaged, selection of the autopilot aileron channel on the pilot's selector will move the aileron feel actuator to the high speed (fully extended) position. This restricts the aileron authority in the event of malfunction of the autopilot in the roll axis at high altitude.

60. At the commencement of an I.L.S.

approach it is necessary to give partial feel relief on the ailerons and elevators. This is achieved by moving the M.F.S. selector switch to G.P. and pulling the auto-pilot track switch to ON, to operate the associated feel actuators.

*Track and glide relay panel*

61. Fitted on the starboard side of the bomb bay is the track and glide relay panel 83P (fig.6 and 7). This panel contains the potentiometers and relays etc., which are used when the aileron, elevator and rudder feel systems are operating under autopilot control. On aircraft with Mod.2409 embodied, relay 759 is disconnected from the rudder channel and potentiometer No.2 is not used.

**Airspeed ranges**

62. The cut-in, cut-out and intermediary setting speeds for the three systems are given in Table 2. The setting speeds are employed during initial adjustment of the systems on installation, and subsequently for servicing purposes as detailed in the servicing test, para.240 to 242 at the end of this chapter.

**Control switches**

63. The artificial feel systems are engaged simultaneously with the starting of their respective group of P.F.C. units, on depression of the double-pole push-switches as described in para.10.

64. Two push-switches are fitted, one to each pilot's control column handle, and serve to select feel relief in the elevator and aileron sense systems.

65. A further push-switch, for selecting feel relief in the rudder system, is mounted on the pilot's fuel gauge panel 2P and suitably labelled. Location of the various switches is shown in fig.2.

**Micro switches**

66. Two micro switches, Burgess Type V3, are employed in each elevator and rudder feel unit. One controls the supplies to the feel control and warning circuits and is operated to connect these supplies by the relief actuator in its extended or feel engaged position. The other micro switch functions as an external limit switch in the retract field circuit of the relief actuator. It is operated to disconnect the supply to the retract field by the fulcrum lever mechanism when it reaches the feel relief position. Illustrations showing the location of these micro switches in the feel units will be found in Sect.3, Chap.4 of this publication.

*Mod.1806*

67. With Mod.1806 embodied, an additional micro switch, Honeywell Type 1EN-N14, is fitted on a bracket attached to the aileron artificial feel unit. This micro switch acts as a second limit switch in the extend field of the aileron feel actuator and is set to operate by a striker pin on the feel unit lever to stop the actuator should the internal limit switch fail. Operation of the switch will also energize the warning indicator circuits (para.133).

**Warning test switches**

68. Three push-button switches, Ref.No. 5CW/5058, are mounted in the warning relay panel 66P. These switches are included one in the warning circuit of each feel system and are labelled AIL-RUD-ELEV. In conjunction with a fixed resistor, these switches are employed to simulate failure conditions in their respective circuits for servicing purposes. Their operation is fully described in the relevant servicing text at the end of this chapter.

**Potentiometers**

69. The airspeed transmitter potentiometers employed to detect variation of airspeed in the control circuit of each system are located adjacent to the respective component box containing that circuit. Those employed to detect variation of airspeed in the warning circuits are located adjacent to the warning panel 66P. In both cases the types employed are as follows:-

Aileron sense
Smith Type 1081PG — Range 150-370 knots

Elevator sense
Smith Type 1028PG — Range 90-460 knots

Rudder
Smith Type 728PG — Range 130-460 knots

The follow-up potentiometers installed in the artificial feel units of the three systems are:-

Smith, Type 514FL (Pre Mod.1883)
Smith, Type 906FL (Post Mod.1883)

The installation of these potentiometers is illustrated in fig.6.

**Feel units**

70. The artificial feel units are installed in the bomb bay of the aircraft, those for elevator sense and rudder on the port side and that for aileron sense on the starboard. These units contain the respective surface centring mechanism, feel mechanism, actuators and the micro switches and follow-up potentiometers of the corresponding feel control circuit. The aileron sense unit contains also the trim actuator for that system.

**Components box**

71. An electrical components box is provided for each feel unit and contains the moving coil relay, the actuator motor field relays, suppressor circuit, trim resistors and circuit fuse for the feel control circuit. In the case of the elevator sense and rudder units, the components box is mounted, together with its associated detector potentiometer, on the respective feel unit. In the case of the aileron sense unit the components box is located, together with its associated potentiometer, slightly aft of the feel unit. An illustration of the components box will be found at fig.6.

**Actuators**

72. The actuators employed to apply variation of feel for the rudder and elevator sense units are Rotax Type A0117/A and A0117/D respectively, the actuators employed to effect feel relief in both cases are Rotax Type A0904. The actuator employed to perform both functions in the aileron sense unit is Rotax Type A1708. The A and D settings of the Type A0117 actuators vary the length of ram travel and are pre-adjusted by the manufacturers. General descriptive details of the three types employed will be found in the 105D-1901 series of Air Publication.

**Indicators**

73. Three illuminated push-pull switches, Page Type C181C5, are mounted across the forward end of the panel attached to the port console 6P. They are labelled FEEL and additionally designated A-R-E. The lamps light to give an amber display indicating a failure in their respective feel system, i.e., aileron sense, rudder or elevator sense. The main warning lamps will be lit simultaneously with the failure lamps. Depressing the switch cancels the main warning lamp indication.

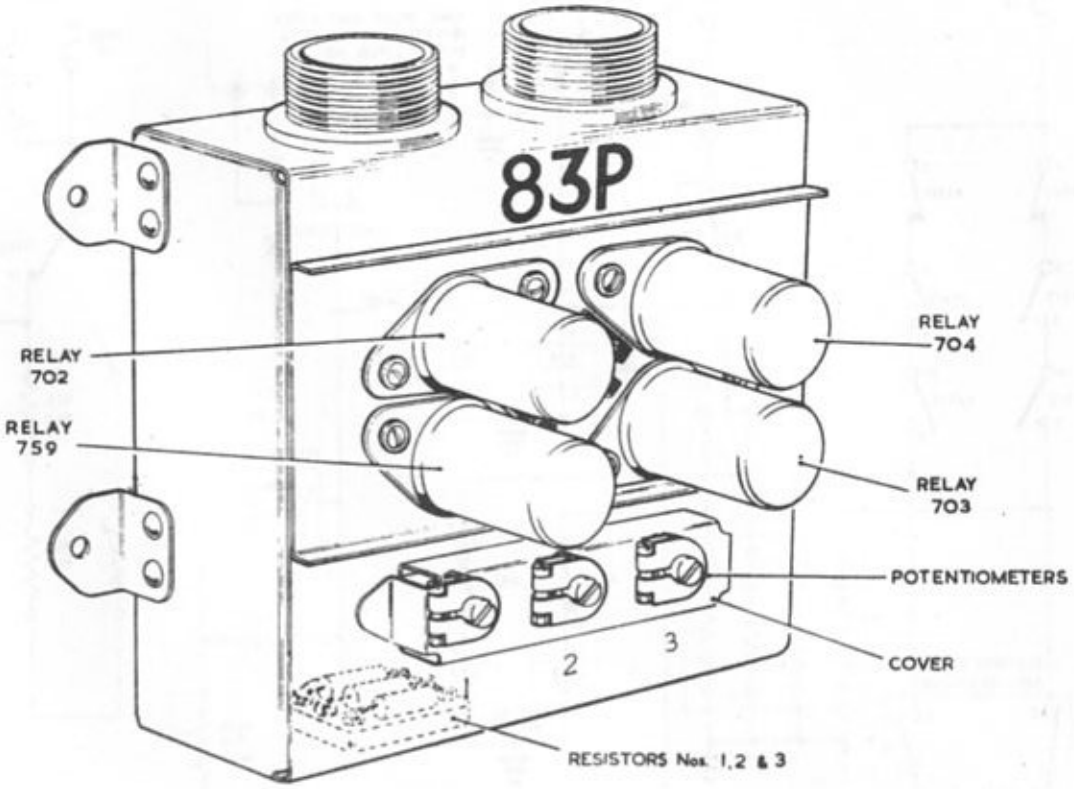



Fig. 7 Track and glide relay panel

74. A 3-position magnetic indicator, Plessey Type 7CZ-107626/75, is mounted adjacent to the first pilots' main warning lamp and labelled P.F.C. UNIT. The indicator is energized giving a black indication during normal flight conditions and de-energized giving a white indication simultaneously with the lighting of the main and individual failure warning lamps. The third indicator position, I.L.S. is not used in this installation.

**Warning relay panel – 66P**

75. This panel is mounted forward of the aileron sense unit on the starboard side of the bomb bay. It contains the indicator relays, moving coil relays, resistors, test switches and rectifiers for the failure warning circuits of the three systems. The three warning potentiometers are mounted adjacent to the panel. Location of the panel is shown in fig.1 and a detailed illustration in fig.6.

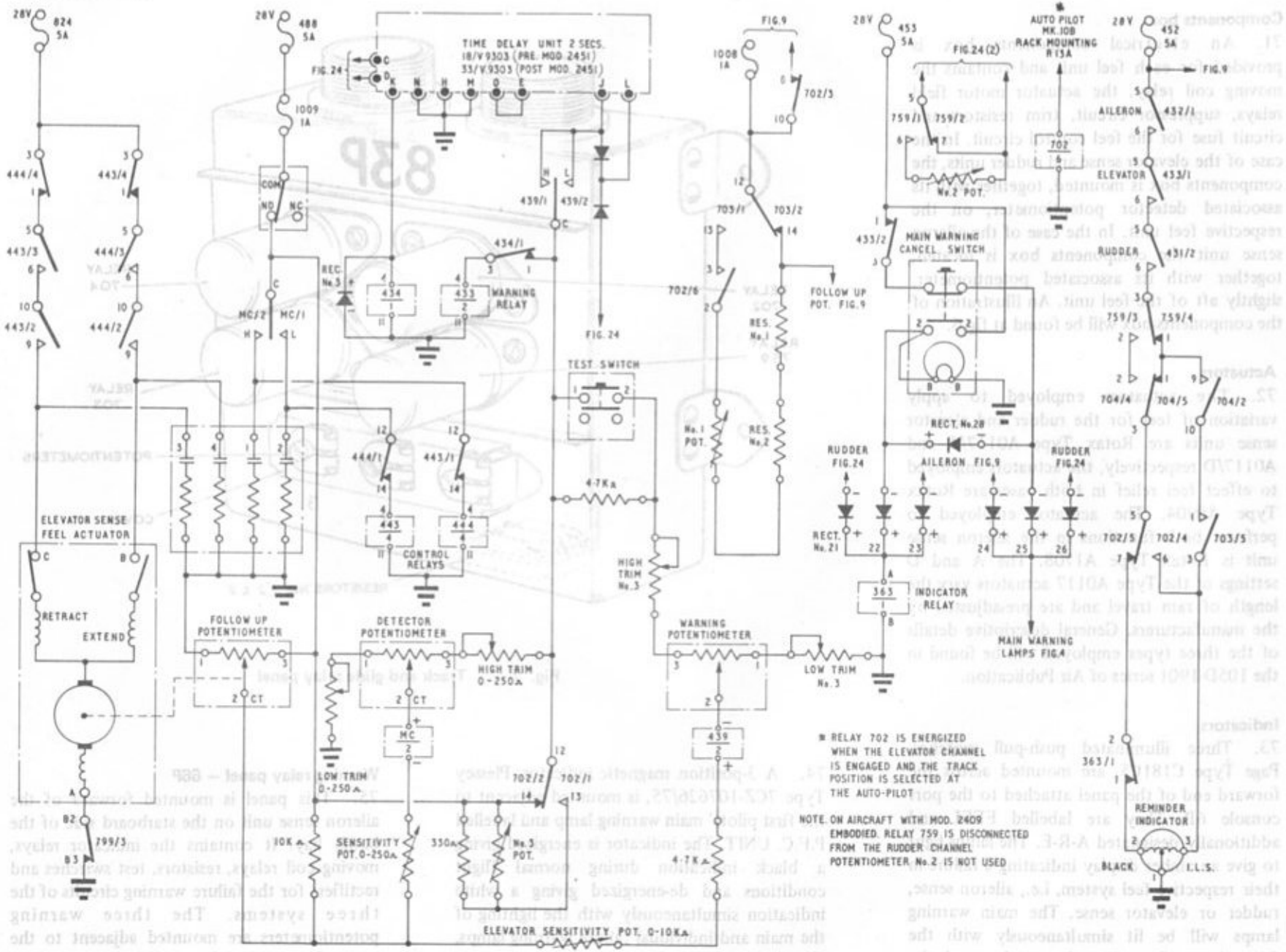



Fig.8 Artificial feel elevator control

▶ *Mod 2451* ◀

**Time delay unit**

▶ 76. A time delay unit is incorporated in the feel circuit to prevent blinking of ◀ the reminder indicator and warning lamps in the following instances of autopilot operation:-

(1) When the elevator channel is engaged and TRACK is selected.

(2) When the rudder channel is engaged.

This is done by inhibiting the operation of relay 434 (elevator feel) and relay 436 (rudder feel) which would otherwise take place as a result of the above selections. The unit is fitted on a bracket which is located adjacent to 66P. A circuit diagram of the unit is given in fig.15, the operation of which is described in para.198.

**Supplies**

77. 28-volt d.c. supplies are fed to the artificial feel systems from fuses in panels 3P, 4P and 26P. Details of fuse numbering will be found in Chap.6 of this section. The engage relays for the systems are mounted on panel 4P. Additional fuses for the supplies to the detector and warning circuits of the three systems are provided in the respective components box.

**Circuit operation**

78. Referring to fig.10 it should be noted that the circuits show the relay and actuator limit switch contact positions which will result when 28-volt d.c. supplies to the fuses are disconnected after normal use i.e., provided feel relief has not been previously selected.

79. It will be seen that when these supplies are disconnected, the systems will remain in the feel engaged condition. The interruption of the hold-in supplies from the fuses, via contacts 130/1, 130/3, 133/1 and 132/1 to the coils of their respective relays, will however have caused these relays to be de-energized causing the following circuit action:-

(1) Change-over of relay contacts 130/1 to 130/2 will interrupt the hold-in supply to the coil of relay 130, and also select the retract field circuit of the aileron relief motor.

(2) Opening of relay contacts 130/3 will interrupt a second hold-in supply to the coil of relay 130, and also isolate the field circuit of the aileron feel motor from fuse 612 (fig.9).

(3) Opening of contacts 133/1 and 132/1 will interrupt the hold-in supplies to their respective relays.

(4) Change-over of contacts 133/2 to 133/3 and 132/2 to 132/3 will isolate the extend field and complete the retract field circuits of their respective motors, via the external limit switches.

80. When 28-volt d.c. supplies are reconnected to the fuses the following circuit action will occur:-

(1) A supply will be fed via fuse 506 and the normally closed contacts 130/2 to the retract field of the aileron sense relief motor. This will cause the actuator to automatically move the mechanism to the relief position, where operation of the internal limit switch, will interrupt the field circuit and stop the motor at that point.

(2) Supplies will be fed via fuses 508 and 507, via the normally closed contacts 133/3 and 132/3 and the external limit switches, to the retract fields of the elevator sense and rudder relief actuators. This will cause the actuators to automatically move their mechanisms to the relief position, where operation of the external limit switches will interrupt the supplies to the retract field and stop movement of the actuators at that point.

(3) Movement of the actuators at (2) from the extend position will:-

(a) Operate the limit switches in the extend fields to close their contacts.

(b) Operate the micro switches (para.66) controlling supplies to the elevator and rudder feel control and warning circuits to disconnect these supplies.

Due to the adjustment of the control circuit in relation to the actuator travel, a very slight movement only will occur of the aileron sense actuator at (1). The internal limit switch in the retract field of the feel motor will be operated to open its contacts, simultaneously with that in the relief motor.

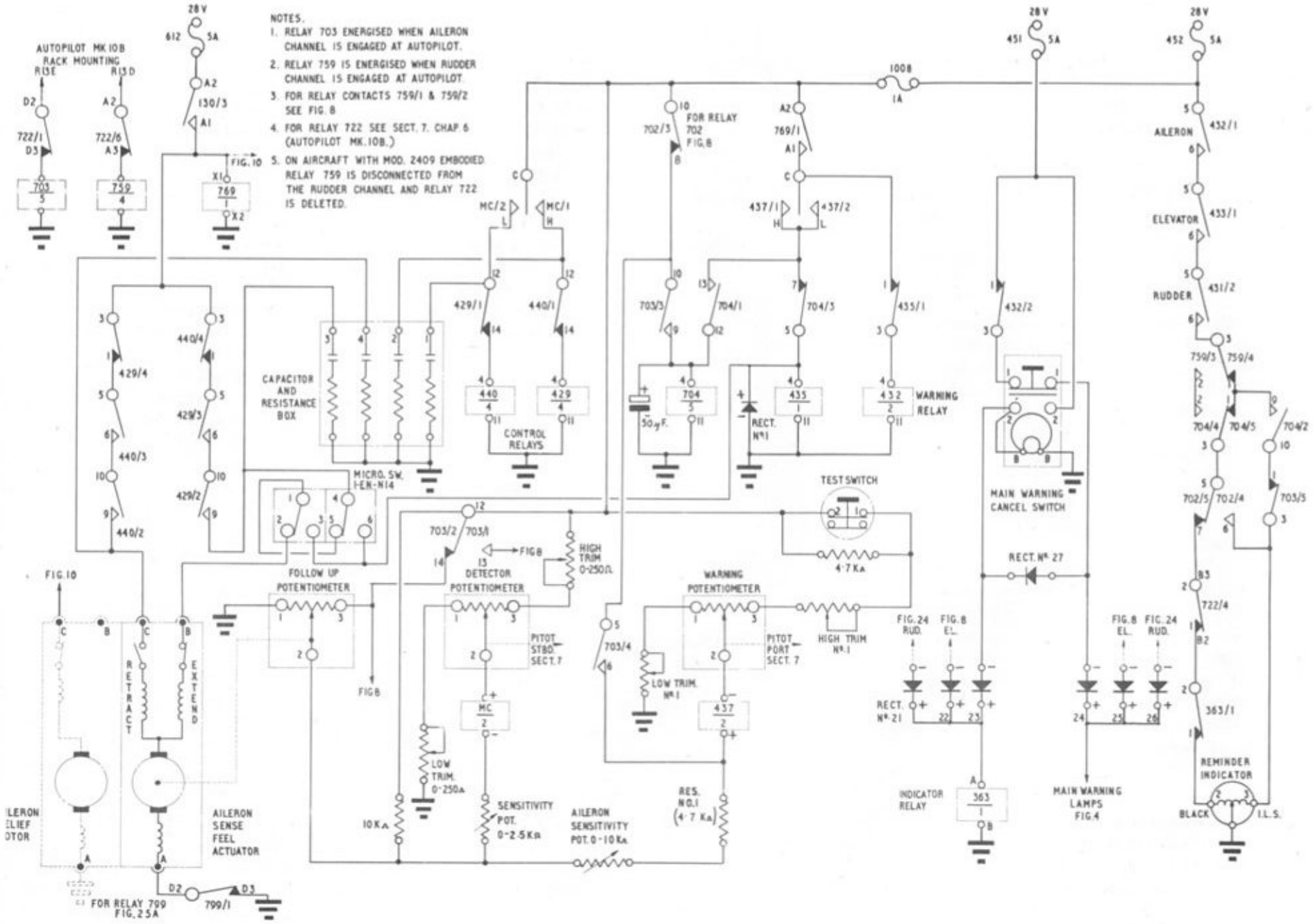



Fig.9 Artificial feel aileron control

*Feel engaged*

81. The following description is given for the elevator sense system but applies also to the rudder system via the respective supplies, switches and relays. The aileron sense system is described separately. Referring to fig.10 it will be seen that momentary depression of the elevator P.F.C. start switch will connect a 28-volt d.c. supply via fuse 509, and switch terminals 3-4, to the coil of relay 133. The earth circuit will be completed via the normally closed contacts 131/2 and the relay will be energized, causing the following circuit action:-

(1) Closing of contacts 133/1 will connect a hold-in supply via fuse 508 to the coil of relay 133.

(2) Change-over of contacts 133/3 to 133/2 will:-

(a) Interrupt the supply circuit to the retract field of the relief actuator.

(b) Connect a supply via fuse 508 to the extend field, causing the actuator to run to the extend or feel engaged position, where movement will be stopped by operation of the internal limit switch in the extend field circuit.

(3) Movement of the actuator from the retract to the extend position will:-

(a) Operate the external limit switch in the retract field circuit to close its contacts.

(b) Operate the micro switch (fig.8) to close its contacts and connect supplies to the control and warning circuits.

82. When the aileron P.F.C. start switch is momentarily depressed, a supply will be fed via fuse 509, and switch terminals 3-4, to the coil of relay 130. The earth circuit will be completed, via the normally closed contacts 131/1 and the relay will be energized, causing the following circuit action:-

(1) Change-over of contacts 130/2 to 130/1 will:-

(a) Isolate the retract field of the relief motor from the supply at fuse 506.

(b) Connect a hold-in supply from fuse 506 to the coil of relay 130.

(2) Closing of contacts 130/3 (fig.9) will:-

(a) Connect the field circuits of the aileron feel motor in readiness for operation under airspeed variation.

(b) Connect a supply via fuse 612 to energize relay 769. Contacts 769/1 will close to feed the control and warning circuits via fuse 452 and 1008.

(c) Connect a second hold-in supply via fuse 612 to the coil of relay 130 (fig.10). (This is a safety measure in the event of failure of fuse 506).

83. Referring to fig.9 will show that when the system is operated to the feel engaged condition, with the aircraft stationary and no airspeed applied, the control and warning relay circuits will be in a state of potential balance. With no current flowing in the moving coil relays the contact arms will be in the central position. Except for variations in the electrical circuit of the aileron sense system, the control and warning relay circuits of the three systems are identical. These variations are as follows:-

(1) The supply to the feel actuator is fed via contacts 130/3.

(2) The supply to the control and warning circuit is fed via contacts 769/1 instead of via a micro switch as in the case of the elevator and rudder feel circuits.

(3) On increasing and decreasing airspeed, change-over to contact H or L at MC/1 and MC/2 will connect supplies to the opposite field in the case of the aileron feel actuator.

*Increasing and decreasing airspeed*

84. The following description is given for the elevator sense system (fig.8) but applies also to the other two systems, via the respective fuses and relays, with mention of the aileron sense variation.

*Increasing airspeed*

85. As the aircraft speed increases to exceed

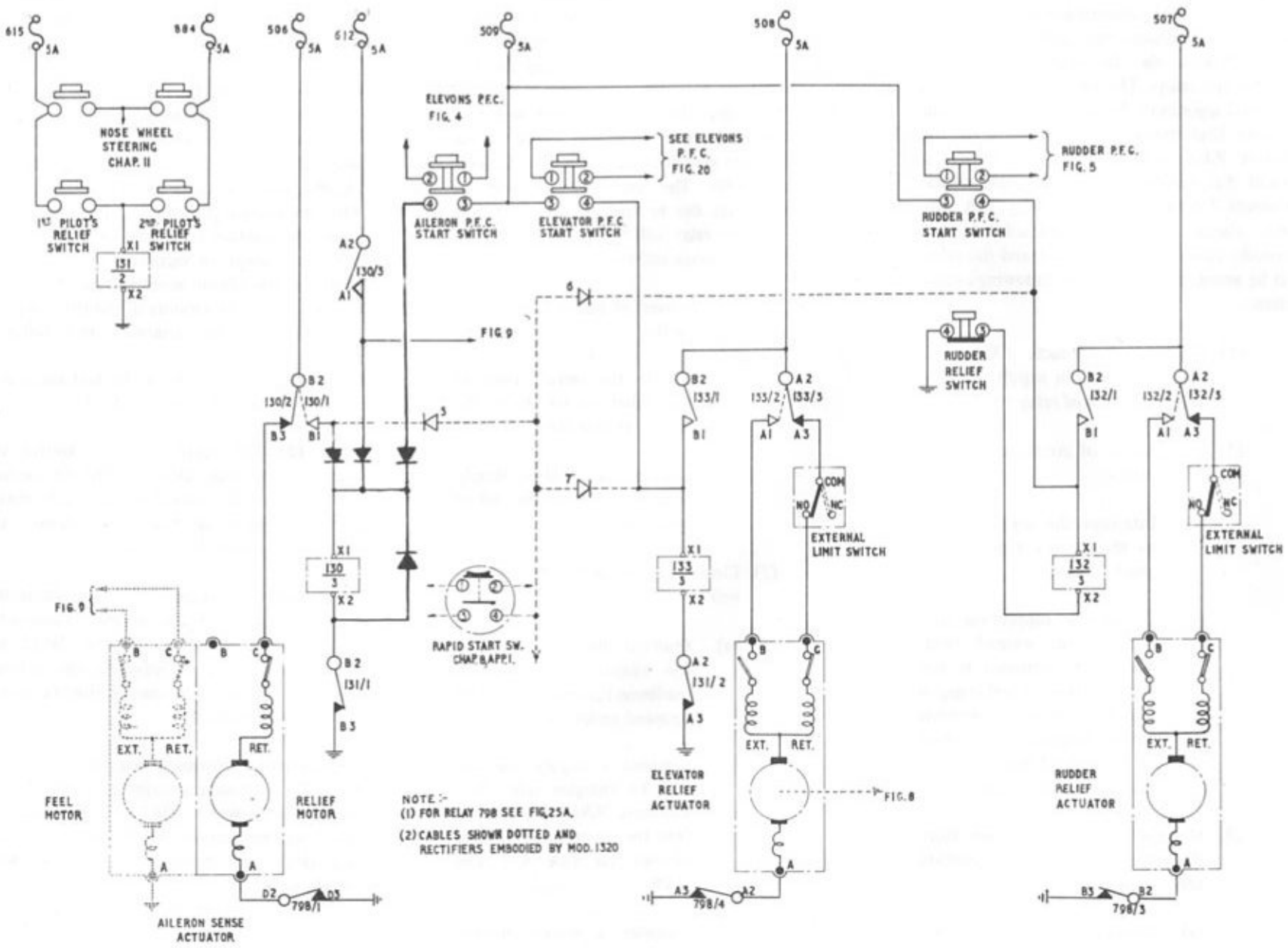



Fig.10 Artificial feel relief

the cut-in speed for the system, the wiper arm of the detector potentiometer will be moved round the resistor to a new position. This movement will cause an out-of-balance potential, between the detector and follow-up wiper arms, which will be applied to the coil of relay MC. The resultant current flow in the coil will in turn cause the following circuit action:-

(1) Relay contacts MC/1 will close to connect a supply via fuse 488 and the micro switch contacts, and contacts 444/1 to energize relay 443.

(2) Contacts 443/1 will open to isolate the coil of relay 444. At the same time, contacts 443/4 will open to isolate the extend field of the actuator, and contacts 443/2 and 443/3 will close to complete the supply from fuse 824 via contacts 444/4 to the retract field of the actuator, which will move accordingly.

86. Movement of the actuator will cause relative adjustment of the feel mechanism which will, in turn, cause the wiper arm of the follow-up potentiometer to move until a new position of potential balance is reached. When this occurs, current will cease to flow in the moving coil relay MC resulting in the following circuit action:-

(1) Relay contacts MC/1 will open to de-energize relay 443.

(2) Contacts 443/1 will open to isolate the coil of relay 444. Also, contacts 443/4 will close to prepare the circuit to the extend field of the actuator, and contacts 443/2 and 443/3 will open to isolate the retract field of the actuator.

87. In the case of the elevator sense and rudder systems, initial movement of the actuator at the cut-in speed for the system, will operate the internal limit switches of the extend field circuits to close their contacts. Adjustment of the mechanisms for increasing airspeed will progressively increase the resistive force being applied to movement of the controls.

88. In the case of the aileron sense system (fig.9) for increasing airspeed, the supply will be connected to the extend field of the feel actuator, via the series contacts 4-5 and 1-2 of the external limit micro switch. The actuator will move accordingly.

89. Initial movement of the actuator at the cut-in speed, will cause operation of the internal limit switches in the retract field circuits of both the feel and relief motor (fig.10), to close their contacts. Such operation will place the aileron sense system at readiness for operation on decreasing airspeed or to the relief position. Adjustment of the aileron sense feel mechanism for increasing airspeed will progressively reduce the angle to which the control surfaces can be operated.

*Decreasing airspeed*

90. Similarly to operation for increasing airspeed, decreasing airspeed will cause an out-of-balance potential to be applied to the moving coil relay MC. In this case however, current flow will be reversed and the following circuit action will result:-

(1) Relay contacts MC/2 will close to connect a supply via fuse 488 and the micro switch contacts, and contacts 443/1 to energize relay 444.

(2) Contacts 444/1 will open to isolate the coil of relay 443. At the same time, contacts 444/4 will open to isolate the retract field of the actuator, and contacts 444/2 and 444/3 will close to complete the supply via fuse 824 and contacts 443/4 to the extend field of the actuator, which will move accordingly.

Movement of the actuator will cause relative adjustment of the feel mechanism and follow-up potentiometer, as at para.86, resulting in the actuator being stopped at the re-adjusted position.

91. In the case of the elevator sense and rudder systems, adjustment of the feel mechanisms for decreasing airspeed will progressively reduce the resistive force being applied to movement of the controls.

92. In the case of the aileron sense system, for decreasing airspeed the supply will be connected to the retract field of the feel motor and the actuator will move accordingly. Adjustment of the feel mechanism for decreasing airspeed will progressively increase the angle to which the control surfaces can be operated.

93. In the manner described in the foregoing paragraphs, the amount of feel being applied is varied automatically in relation to airspeed,

between the cut-in and cut-out speeds for the respective system. Movement of the feel actuators in the elevator sense and rudder systems and the feel motor on the aileron sense system is stopped at these points as follows:-

(1) Increasing airspeed above cut-out.

(a) Elevator - sense: detector potentiometer ceases to respond (retract field limit switch remains closed).

(b) Aileron - sense: extend field limit switch contacts open.

(c) Rudder - retract field limit switch contacts open.

(2) Decreasing airspeed below cut-in.

(a) Elevator - sense: extend field limit switch contacts open.

(b) Aileron - sense: detector potentiometer ceases to respond (retract field limit switch remains closed).

(c) Rudder - extend field limit switch contacts open.

*Feel relief*

94. Fig.10 will show that selection of feel relief in the aileron and elevator sense system is effected simultaneously on depression of the either pilots' relief switch. Circuit operation for selection of feel relief in the rudder system is similar, except that operation of the normally closed contacts of the rudder relief switch replaces that of the cut-out relay. The following description therefore is given for the elevator sense system, but will apply to the other two systems via the respective supplies, switches and relays.

95. On momentarily depressing either pilots' relief switch, a supply will be fed via fuse 615 or 884 to energize relay 131. The following circuit action will then take place:-

(1) Opening of contacts 131/2 will interrupt the earth circuit of relay 133 which will be de-energized.

(2) Opening of contacts 133/1 will disconnect the hold-in supply to relay 133 via fuse 508.

(3) Change-over of contacts 133/2 to 133/3 will transfer the supply at fuse 508, from the extend field of the relief actuator to the retract field via the external limit switch. The actuator will be moved accordingly.

(4) Movement of the actuator from the extend position will close the limit switch in the extend field in readiness for further operation. Movement of the mechanism to the relief position will operate the external limit switch to open its contacts, thus disconnecting the supply to the retract field, and the actuator will stop at that point. In addition the contacts of the micro switch controlling the feel and warning circuits will be opened to give warning indication (para.134).

In the case of the aileron sense unit, movement of the actuator will be stopped when the mechanism reaches the relief condition, by operation of the internal limit switch in the retract field of the relief motor. It should be noted that under conditions of failure where feel relief is selected for either the elevator or aileron system, re-engagement of feel in the system not subject to failure, should this be required, is then effected by operation of the respective P.F.C. group start switch.

*Feel and feel relief locking*

96. Should the control switch for the feel and feel relief locking circuits be selected to LOCK (fig.25A), supplies from fuses 923 and 978 will be fed via the respective contacts of the switch to energize relays 799 and 798. The earth returns for the feel and feel relief actuators, which are completed via the normally closed contacts of the relays will then be broken, and the actuators will stop in the selected position. At the same time the indicator will be lit from fuse 923 via the series contacts C1-C2 of the relays.

*Mod.1320*

97. When Mod.1320 has been embodied, the artificial feel circuits will be energized simultaneously with rapid starting of the aircraft engines.

98. Operation of the appropriate control switches (Chap.8, App.1) will connect a supply via fuse 674 and three rectifiers direct to the coils of relays 130, 132 and 133. Referring to

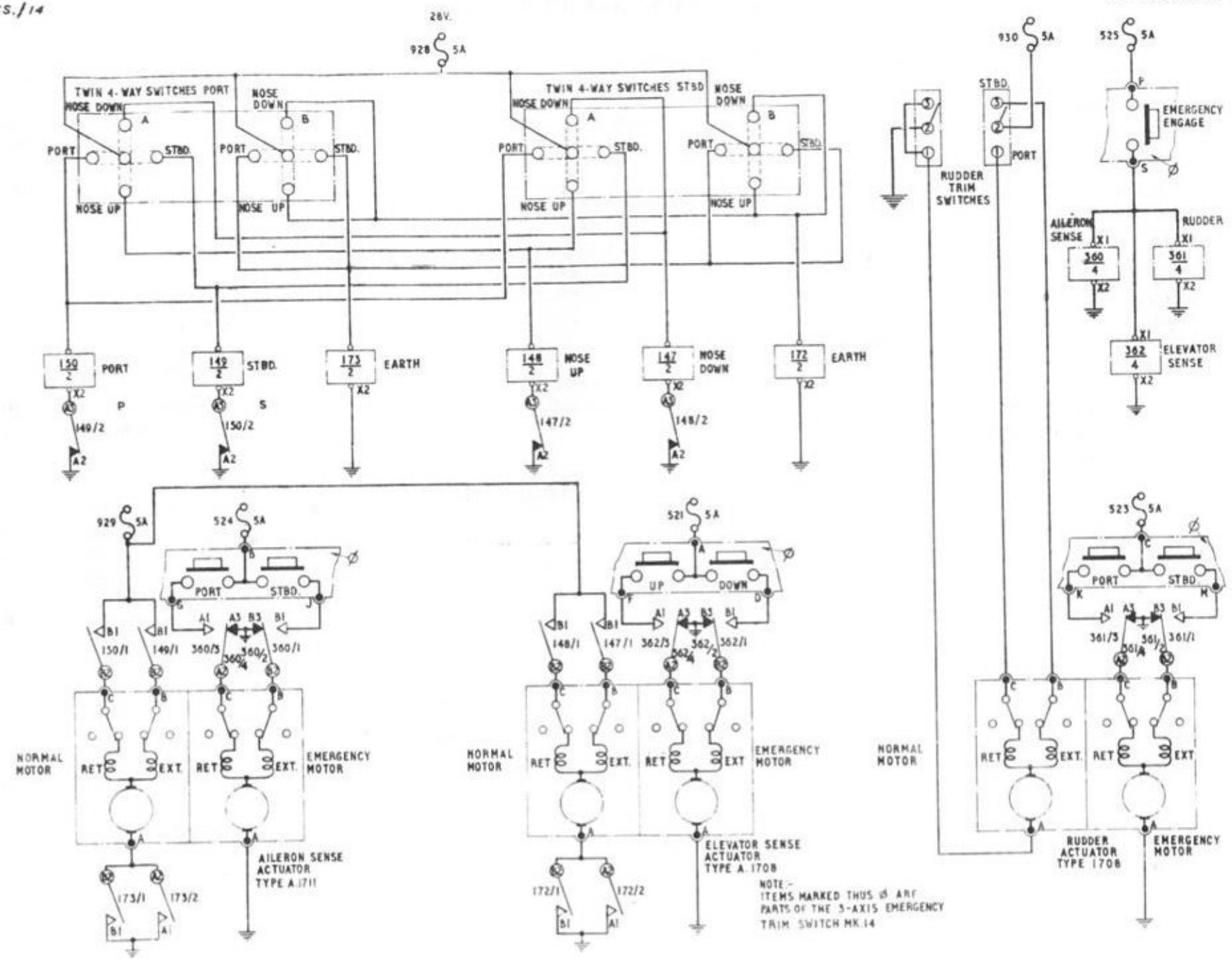



Fig. 11 Normal and emergency trim controls

◄ Corrections to actuator field coils ►

fig.10 it can be seen that this supply will by-pass the start switches of the three systems, thus eliminating the normal starting sequences.

*Aileron channel selected*

99. It will be appreciated that under normal circuit conditions, a balance of potential will exist between the follow-up, detector and warning potentiometers so that the associated moving coil relays will be de-energized. Referring to fig.9, it will show that when the autopilot aileron channel is selected, relay 703 will be energized to provide the following circuit action :-

(1) Contacts 703/3 will close to connect a supply from fuse 452 via fuse 1008 to energize relay 704.

(2) Contacts 703/4 will close to connect a direct supply to the coil of relay 437.

(3) Change-over of contacts 703/2 to 703/1 (fig.8) will remove the supply from the follow-up potentiometer and prepare part of the retract circuit for the aileron feel actuator.

With relay 704 energized:-

(4) Contacts 704/1 will close to prepare a hold-in supply to the coil of relay 704.

◀ (5) Contacts 704/3 will open to isolate relay 435.

(6) Contacts 704/5 will open to de-energize the reminder indicator which will show white. ▶

100. The opening of contacts 703/2 and the closing of contacts 703/4 will cause an out-of-balance condition in the potentiometer circuits and, as a result, relays MC and 437 will be energized to cause the following circuit action:-

(1) Contacts 437/1 will close to connect a hold-in supply from fuse 452, via fuse 1008, contacts 769/1 (para.82) and 704/1 to the coil of relay 704.

(2) Contacts MC/1 will close to energize relay 429 from fuse 452, via fuse 1008 and contacts 440/1.

With relay 429 energized:-

(3) Contacts 429/1 will open to isolate relay 440.

(4) Contacts 429/4 will open to isolate the retract field of the feel actuator.

(5) Contacts 429/2 and 429/3 will close to energize the extend field of the actuator via fuse 612.

The actuator will move to the fully extended (high speed) position.

101. Therefore, upon selection of the autopilot aileron channel, the aileron feel actuator will move out to the high speed position and the reminder indicator will be de-energized to show white. It should be noted that contacts MC/1 and 437/1 will remain closed until the aileron channel is disengaged (but see 'Track selection').

*Track selection*

102. During an I.L.S. approach under autopilot control (para.60) selection of the autopilot TRACK switch will energize relay 702 (fig.8). This action will give partial feel relief on both elevator and aileron systems. Reference to fig.8 will show that with relay 702 energized, the operation will be as follows:-

(1) Contacts 702/5 will open to isolate the reminder indicator, already de-energized (para.99(6)).

(2) Contacts 702/6 will close to supply the aileron follow-up potentiometer via No.1 pot. and No.1 and 2 resistances (aileron circuit).

◀ (3) Contacts 702/2 will change-over to make at 702/1. This action will bring No.3 pot into the circuit to reduce the voltage applied to the warning and detector potentiometers (elevator circuit). ▶

103. The potential balance between the potentiometers will be upset so that relay MC will be energized to close contacts MC/2. As a result, the extend field of the elevator feel actuator will be energized to operate the actuator in the manner described in para.90. Movement of the follow-up potentiometer will restore the potential balance, when relay MC will be de-energized and the actuator will stop. Thus partial feel relief will be given on the elevator system.

104. Relay 439 will be operated simultaneously with relay MC and a supply will

be connected, via its contacts, to the time delay unit. The time delay unit will prevent relay 434 being energized during its two seconds operation, when the actuator will have moved the wiper arm of the follow-up potentiometer sufficiently to stabilize the circuit and de-energize relays MC and 439. The prevention of relay 434 being energized during this period will ensure that no spurious indication is given.

105. In the case of the aileron circuit (fig.9), relay MC will be energized due to the unbalance created by the closing of contacts 702/6. It should be noted however that this relay will be energized in opposite sense to that when the aileron channel was selected, (para.100), i.e., contacts MC/1 will change-over to close MC/2.

106. When contacts MC/1 open, relay 429 will be de-energized to open contacts 429/2 and 429/3, and close contacts 429/1 and 429/4. When contacts MC/2 close, relay 440 will be energized to open contacts 440/1 and 440/4 and close contacts 440/2 and 440/3. A supply from fuse 612 will then be made via the appropriate relay contacts, to the retract field of the aileron feel actuator. Operation of the actuator in the retract direction will move the follow-up potentiometer to restore the circuit balance, when relay MC will be de-energized to stop further movement of the actuator.

*Track disengage*

107. When the TRACK switch is pressed to the off position, relay 702 (fig.8) will be de-energized to reconnect the circuit for normal operation, when conditions prior to track selection will prevail. It should be noted, as in case of track selection, that the time delay unit will ensure that relay 434 remains de-energized during the transition period (i.e., until the circuit is a gain stabilized) thus preventing spurious warning indication.

*Aileron channel disengage*

108. When the aileron channel is disengaged, relay 703 (fig.9) will be de-energized and the circuit will revert to normal. Until the circuit is stabilized, however, the de-energizing of relay 704 will be delayed by the action of the capacitor connected across its coil, thus preventing spurious warning indication.

**Autopilot control (post Mod.1856)**

109. The following paragraphs describe the circuit operation for autopilot Mk.10B control of the artificial feel circuits during normal flight and I.L.S. approach.

*Aileron channel selected*

110. Under normal circuit conditions a balance of potential will exist between the follow-up, detector and warning potentiometers, so that the associated moving coil relays will be de-energized. When the autopilot aileron channel is selected, relay 703 (fig.9) will be energized via permanently closed contacts 722/1 to provide the following circuit action:-

*NOTE . . .*
*Relay contacts 722/1, 3, 4 and 6 will be permanently closed Post Mod.2263, Sect.7, Chap.6.*

(1) Contacts 703/3 will close to connect a supply from fuse 452 via fuse 1008 and normally closed contacts 702/3 to energize relay 704.

(2) Contacts 703/4 will close to connect a direct supply to the coil of relay 437.

(3) Change-over of contacts 703/2 to 703/1 will isolate the supply from the follow-up potentiometer and prepare part of the retract circuit for the aileron feel actuator.

(4) Contacts 703/5 will open to isolate the I.L.S. coil of the reminder indicator.

With relay 704 energized:-

(5) Contacts 704/1 will close to prepare a hold-in supply to the coil of relay 704.

(6) Contacts 704/3 will open to isolate relay 435.

(7) Contacts 704/2 will close to prepare the circuit to the I.L.S. coil of the reminder indicator, and change-over of contacts 704/5 to 704/4 will de-energize the indicator to show white (but see para.113).

111. The opening of contacts 703/2 and closing of contacts 703/4 will cause an out-of-balance condition in the potentiometer circuits and, as a result, relays MC and 437 will be energized to cause the following circuit action:-

(1) Contacts 437/1 will close to connect a hold-in supply from fuse 452, via fuse 1008, contacts 769/1 (para.82) and 704/1 to the coil of relay 704.

(2) Contacts MC/1 will close to energize relay 429 from fuse 452, via fuse 1008 and contacts 440/1.

With relay 429 energized:-

(3) Contacts 429/1 will open to isolate relay 440.

(4) Contacts 429/4 will open to isolate the retract field of the feel actuator.

(5) Contacts 429/2 and 429/3 will close to energize the extend field of the actuator via the series contacts 4-5 and 1-2 of the external limit micro switch.

The actuator will now move to the fully extended (high speed) position.

112. Therefore, upon selection of the autopilot aileron channel, the aileron feel actuator will move out to the high speed position and the reminder indicator will be de-energized to show white. However, with the rudder channel also selected, the indicator will be energized to show black (para.113). It should be noted that contacts MC/1 and 437/1 will remain closed until the aileron channel is disengaged (but see 'Track selection').

*Rudder channel selected*

113. When the autopilot rudder channel is selected, relay 759 (fig.9) will be energized via the normally closed contacts 722/6 to provide the following circuit action:-

(1) Change-over of contacts 759/2 to 759/1 will connect No.2 pot. in series with the follow-up potentiometer. This will create a state of unbalance in the circuit and relays MC and 438 will be energized.

(2) Change-over of contacts 759/4 to 759/3 will energize the reminder indicator to show black (Contacts 704/4 are already closed by selection of the aileron channel).

114. With relays MC and 438 energized, the following circuit action will result:-

(1) Contacts MC/1 will close to connect a supply from fuse 487, via fuse 1010, the micro switch contacts and contacts 12-14 of relay 442, to energize relay 430.

(2) A supply from fuse 817 will be made via the respective contacts of relays 442 and 430 to the retract field of the rudder feel actuator. The actuator will retract to a position where the rudder forces opposing the autopilot are increased by 50%. At this point, the balance of potential in the circuit will be restored by the movement of the follow-up potentiometer, and relay MC will be de-energized. Relay 430 will thus be de-energized in turn to stop further actuator movement.

(3) Operation of relay 438 contacts will energize the time delay unit via pole L which will prevent the supply via poles D and C from energizing relay 436 for 2 seconds, during which time the balance of potential will have been restored and relay 438 de-energized. This prevents blinking of the reminder indicator and warning lamps.

◀ *Note...*
*On aircraft with Mod.2409 embodied, relay 759 is disconnected from the rudder channel and potentiometer No.2 is not used. Also relay 722 is deleted.* ▶

*Track selection*

115. During an I.L.S. approach under autopilot control, selection of the autopilot TRACK switch will energize relay 702. This action will give partial feel relief on both elevator and aileron systems. With relay 702 energized, the operation will be as follows:-

Elevator feel

(1) Change-over of contacts 702/2 to 702/1 will bring No.3 pot. and the 330-ohm resistor into the circuit to reduce the voltage applied to the warning and detector potentiometers. The potential balance between the potentiometers will be upset so that relay MC will be energized to close contacts MC/2. As a result, the extend field of the actuator will be energized to move the actuator as described in para.90. Movement of follow-up potentiometer will restore the potential balance, when relay MC will be de-energized and the actuator will stop. Thus partial feel relief will be given on the elevator system.

(2) Relay 439 will also be operated simultaneously with relay MC and the supply via No.3 pot. and the 330-ohm resistor and contacts 702/1 will be made across the

contacts of relay 439 to energize the time delay unit via pole L. This will prevent the supply via poles J and K from energizing relay 434 for 2 seconds, during which time the balance of potential will have been restored and relay 439 de-energized. This prevents blinking of the reminder indicator and warning lamps.

Aileron feel

(3) In the case of the aileron circuit, relay MC will be energized due to the unbalance created by the closing of contacts 702/6. It should be noted however that this relay will be energized in the opposite sense to that when the aileron channel was selected, (para.111), i.e. contacts MC/1 will change-over to close contacts MC/2. This action will de-energize relay 429 and energize relay 440, the result of which will isolate the extend field of the actuator and energize the retract field. The actuator will retract until the follow-up potentiometer restores the circuit balance, when relay MC will be de-energized to stop further actuator movement.

(4) Contacts 702/3 will open to remove the supply to the coils of relays 704 and 437. However, these two relays will remain energized by the hold-in supply through contacts 437/1 and 704/1 (para.111), the path to relay 437 being completed via contacts 703/3 and 703/4.

Reminder indicator

(5) Change-over of contacts 702/5 to 702/4 will energize the reminder indicator to show I.L.S. (via - contacts 759/3 and 704/4).

*Track disengage*

116. When the TRACK switch is pressed to the off position relay 702 will be de-energized to reconnect the circuit for normal operation, when conditions prior to Track selection will prevail. Until the circuit stabilizes, the time delay unit will prevent relay 434 being energized, thus preventing spurious indication.

*Aileron channel disengage*

117. When the aileron channel is disengaged, relay 703 will be de-energized and the circuit will revert to normal. Until the circuit stabilizes, the capacitor connected across the coil of relay 704 will delay the relay being de-energized, thus preventing spurious indication.

*Rudder channel disengage*

118. When the rudder channel is disengaged, relay 759 will be de-energized and the circuit will revert to normal. Until the circuit stabilizes, the time delay unit will prevent relay 436 being energized, thus preventing spurious indication.

**Failure warning system**

119. Failure warning for the three feel systems is provided by the following:-

(1) System warning lamps.

(2) Main warning lamps.

(3) Reminder indicator.

*System warning lamps*

120. The individual system warning lamps are housed in their respective push-pull switches. They will light to indicate failure in the respective systems due to either the feel control or failure warning circuits ceasing to follow airspeed variation. The lamps will be lit also when the systems are operated to the relief position.

*Main warning lamps*

121. The lamps of the main warning circuit will light simultaneously with those for the individual systems as above. Depressing the respective warning push-pull switch will disconnect the supply to the main lamps in respect of the failed circuit and they will extinguish.

*Reminder indicator (post Mod.1856)*

122. Under normal conditions, this indicator (3-position) is energized black by a supply from fuse 452, which is fed via the series connected contacts of the warning relays 432, 433 and 431, and the normally closed contacts of relays 759, 704, 702, 722 and the indicator relay 363. Operation of any of the warning relays due to failure conditions will cause the indicator to be de-energized to show white simultaneously with the lighting of the respective system and the main warning lamps.

*Main warning cancel effect*

123. The operation of any main warning

cancel switch, by energizing the indicator relay 363, will cause the reminder indicator to remain de-energized to show white when the main warning lamps are out. The indicator then serves as a reminder to the pilot that a failure has occurred, and reference to the system warning lamps will confirm in which system the failure exists (Refer to paras. dealing with failure under autopilot control).

*Indicator relay*

124. In the event of a failure, the normally closed contacts of this relay are opened in conjunction with the contacts of the warning relays. The supply, initially to energize the coil of this relay, is fed via the normally closed contacts of the warning relay and the main warning cancel switch for the respective system.

125. Depression of the main warning cancel switch connects a hold-in supply to the coil of the indicator relay, thus causing the contacts to remain open and the indicator to remain de-energized.

*Circuit operation*

126. Reference to the elevator, aileron and rudder feel circuits will show that the failure warning circuits of the three systems differ only in that the supply to the warning relays (in the case of the aileron sense system), is fed via the contacts of a relay instead of a micro switch.

127. Opening and closing of the respective contacts in the three circuits, however, occur in the same operating sequence for each feel system. This being the case, the following operation, which is given for the elevator circuit, will also apply to the other two circuits, taking into consideration the appropriate fuses and controls.

128. As previously described, disconnection and reconnection of the 28-volt d.c. supply to the aircraft after normal use, will cause the system to move automatically to the feel relief position (para.50).

129. When this occurs, the micro switch will be operated to open its contacts, thus disconnecting the supply from fuse 488 to relay 433, which will be de-energized. The following circuit action will then take place:-

(1) Opening of relay contacts 433/1 will interrupt the supply to the reminder indicator which will be de-energized to show a white face.

(2) Closing of relay contacts 433/2 will connect a supply to operate the indicator circuit as follows:-

(a) Light the system warning lamp.

(b) Energize the coil of relay 363. Opening of normally closed contacts 363/1 will then isolate the reminder indicator from the warning circuit.

*Feel engaged*

130. When feel is engaged, the micro switch contacts will be closed and a supply will be fed, from fuse 488, via switch contacts COM-NO and normally closed relay contacts 434/1, to the coil of relay 433 which will be energized. The following circuit action will then take place:-

(1) Closing of relay contacts 433/1, in conjunction with the closing of contacts 432/1 and 431/1 as feel is engaged in the aileron sense and rudder systems respectively, will connect a supply to contacts 363/1.

(2) Opening of the normally closed relay contacts 433/2 will disconnect the supply from fuse 453, to the system warning lamp which will go out, to the main warning lamp and to the coil of relay 363. Similar operation in the aileron sense and rudder systems will cause relay 363 to be de-energized.

(3) Closing of relay contacts 363/1, will complete the supply at (1) to the indicator which will be energized to show a black face.

131. Under normal conditions, as airspeed varies the adjustment of the detector potentiometer wiper arm, a simiar variation will occur of the warning potentiometer wiper arm. Whilst the feel unit is responding correctly the follow-up potentiometer will be relatively adjusted to airspeed variation and an out-of-balance potential will not therefore develop to operate relay 439. The contact arm of relay 439 will remain in the central neutral position and the indications for feel engaged will remain unchanged during flight.

*Failure*

132. Should a failure occur in the operation of any of the circuits, an out-of-balance potential will develop between the wiper arms of the follow-up and warning potentiometers.

Regardless of which direction the resultant current flows in the coil of relay 439, the closing of contacts 439/1 or 439/2 will connect a supply from fuse 488 via fuse 1009, and the micro switch to the time delay unit (poles K and L Pre. Mod.1856, poles J and L Post Mod.1856). After a period of 2 seconds the time delay unit will complete the supply to energize relay 434, when the following circuit action will take place:-

(1) Opening of the normally closed contacts 434/1 will disconnect the supply to the coil of relay 433 which will be de-energized.

(2) Opening of contacts 433/1 will interrupt the supply from fuse 452 to the reminder indicator which will be de-energized to show a white face.

(3) Closing of contacts 433/2 will connect a supply from fuse 453, (para.129) lighting the system and main warning lamps and energizing relay 363.

(4) Opening of contacts 363/1 will disconnect the reminder indicator from the warning circuit.

133. Considering the aileron feel circuit, should actuator runaway cause the 2nd limit switch to operate (para.67), the series contacts 4-5, 1-2 of the micro switch will open to stop further movement of the actuator. Also contacts 4-6 will close to energize relay 435 with the following results:-

(1) Contacts 435/1 will open to de-energize relay 432.

(2) Contacts 432/1 will open to de-energize the reminder indicator to show a white face.

(3) Contacts 432/2 will close to light the system and main warning lamps and energize relay 363.

*Feel relief*

134. Operation of the feel relief switch will cause operation of the micro switch to open contacts COM-NC. Relay 434 will be de-energized and contacts 434/1 will revert to the normally closed position. As a supply is not now available from fuse 488, relay 433 will remain de-energized. The indications will therefore continue as for failure at (2), (3) and (4) in para.132.

*Main warning cancel*

135. Depression of the cancel switch will now cause the following circuit action to occur:-

(1) Disconnection of terminals 1-1 will disconnect the supply from fuse 453, via contacts 433/2 to the main warning lamps which will go out.

(2) The supply from fuse 453 at (1) will be fed instead via terminals 2-2, continuing to light the individual warning lamp and energize relay 363.

(3) Contacts 363/1 will remain open, causing the indicator to remain de-energized and giving a white display to remind the pilot that a failure has occurred.

*Failure under autopilot control*

136. Under autopilot control, warning of feel failure is confined to the system warning lamps and main warning lamps, since the reminder indicator is already de-energized to show white by relay 704 being energized (para.99). The indicator coil is further isolated by relay 702 being energized when TRACK is selected.

▶◀

## NORMAL AND EMERGENCY TRIM

137. Aircraft trim adjustment is effected by electrically operated actuators coupled in the control rod systems of the three flying surface axes, i.e., aileron sense, elevator sense and rudder.

138. Extension, or retraction of the actuators causes movement of the control rod system, thus adjusting the control and surface neutral positions to any required angle within the range of the actuator travel.

139. In the case of the elevator sense, extension or retraction of the actuator will cause nose down or nose up trim respectively. In the case of the aileron sense and rudder, extension or retraction of the actuator will cause trim to starboard or port respectively. Two motor linear actuators are employed to provide for this requirement. Separate control circuits are provided to operate one motor of each actuator for normal conditions and the other motor for emergency conditions.

**Control switches**

*Normal*

140. Four single-pole, four-way toggle switches, spring-returned to a centre off position, are provided to control the elevator

and aileron sense normal trim circuits. These switches are fitted two in each pilot's control handle and arranged in line with the longitudinal axis of the aircraft. The forward switch in each handle controls the supply circuits for the normal motors of both systems and is designated A on the routing chart, circuit diagram and descriptive text provided for the installation. The aft switch in each handle controls the earth circuits of both motors and is designated B.

141. A mushroom type button is provided on each handle to give simultaneous operation of both toggles for functional use. This button is hinged to the toggle of the aft switch and secured to the toggle of the forward switch by a spring loaded locking pin. Depressing the locking pin allows the button to be hinged upwards and the switch toggles can then be operated independently for circuit servicing purposes. Care should be taken when replacing the button to ensure that both toggles are in the centre off position and it should be noted that the locking pin has to be depressed to engage the securing device.

142. The switches provide four positions on two axes, operation of the button forward or aft on the longitudinal axis causes nose down or nose up trim respectively in the elevator sense system. Operation of the button to port or starboard in the lateral axis causes corresponding trim in the aileron sense system.

143. Control of the circuit for rudder trim under normal conditions is effected by two single-pole switches, Ref.No. 5CW/5822, mounted together on the fuel contents panel 2P and labelled RUDDER TRIM, PORT-STARBOARD. These switches are fitted one each in the supply and earth circuits of the motor and are spring-returned to a centre off position. A split toggle link provides for simultaneous operation of both switches for functional purposes or separate operation for servicing purposes.

144. Interruption of the motor earth circuits in the case of the three systems as described in the above paragraphs ensures non-operation of any of them by supplies other than via the respective control switches.

*Emergency*

145. Control of the emergency or stand-by circuits of the three systems is effected by a switch, Type 101, which is mounted at the forward end of the retractable centre console 5P. This switch provides six positions in three axes as follows:-

(1) Longitudinal for elevator sense, forward or aft positions causing 'nose down' or 'nose up' trim respectively.

(2) Lateral for aileron sense, port or starboard positions causing trim accordingly.

(3) Rotation of the centre knob for rudder trim, anti-clockwise causing trim to port and clockwise trim to starboard.

A spring-returned push-switch forms the centre of the control knob, the button of which is engraved SS FOR EMERGENCY TRIM'. This has to be held in the depressed position throughout all emergency trim operations.

**Actuators**

146. Three two motor linear actuators are employed, one in the trim system of each flying control axis, i.e., aileron sense, elevator sense and rudder. One motor serves to apply trim under normal conditions whilst the other is provided as a stand-by. The motors drive a common extension shaft through a differential gearbox. The actuators of the elevator sense and rudder trim systems are fitted in the control rod runs adjacent to the respective artificial feel unit. That for the aileron sense trim system is contained in the artificial feel unit. The types employed are as follows:-

| | | |
|---|---|---|
| Aileron | - | Rotax Type A.1711 |
| Rudder | - | Rotax Type A.1708 |
| Elevator | - | Rotax Type A.1709 |

Descriptive details for these actuators will be ◀ found in A.P.113E-0189-1. ▶

**Supplies**

147. 28-volt d.c. supplies are fed to the control circuits and the actuators from fuses in panels 3P and 4P. Details of the fuses employed will be found in Chap.6, of this section.

**Circuit operation**

148. Referring to fig.11, as the amount of trim normally required comes within the limits of the actuator travel, the internal limit switches are shown in the closed condition. As the circuits for elevator sense trim, nose up or down and aileron sense trim, port or starboard, are identical, the following description is given for aileron sense port trim. It will also apply to the other circuits via the respective relays. The rudder system is described separately.

*Normal*

149. When 28-volt d.c. supplies are connected

to the fuses, operation of either pilots switch to the left on the lateral axis will select aileron sense port trim and cause the following circuit action to occur:-

(1) A supply will be fed from fuse 928 via the section A contacts of the switch to the coil of relay 150. The earth circuit will be completed via normally closed relay contacts 149/2 and the relay will be energized.

(2) A supply will be fed from fuse 928, via the section B contacts of the switch, to the coil of relay 173 which will be energized.

(3) Opening of the normally closed relay contacts 150/2 will interrupt the earth circuit of relay 149 thus ensuring its non-operation throughout port trim adjustment.

(4) Closing of relay contacts 150/1 will connect a supply from fuse 929 to the retract field of the aileron sense normal trim motor.

(5) Closing of relay contacts 173/1 and 173/2 will complete the earth circuit of the motor, which will run, moving the actuator and adjusting trim accordingly, as long as the switch is held in the port selection.

On releasing the switch to the centre off position, the energizing supplies to relays 150 and 173 will be disconnected and the resultant operation of their contacts will stop the actuator at the required trim position.

150. Operation of the rudder switches for port or starboard trim will connect a supply via fuse 930 to the retract or extend field, respectively, of the rudder normal trim motor. The earth circuit will be completed via the contacts of the earth switches, and the actuator will be moved to adjust trim as long as the switch is held in the selected position. When the switch is released to the centre off position the supply and earth circuits will be interrupted and the motor will be stopped at the required trim position.

*Emergency*

151. Operation of the emergency switch push-button will cause a supply to be fed from fuse 525, via the push-switch contacts, to relays 360, 361 and 362 which will energize. Change-over of the contacts of these relays will:-

(1) Disconnect the field circuits of the emergency trim motors for the three systems from earth.

(2) Connect the field circuits of the three emergency motors to the emergency switch contacts, in readiness for the operation of the switch to whichever trim selection is required.

152. Operation of the emergency switch knob to the left in the lateral axis will select aileron sense port trim and the following circuit action will then take place:-

◀(1) A supply will be fed from fuse 524, via pole G and relay contacts 360/3, to the retract field of the▶ emergency trim motor. The motor will run, moving the actuator and adjusting trim accordingly as long as the emergency switch knob is held at the port trim selection.

153. On returning the knob of the emergency switch to the centre off position, the supplies to the actuator emergency motor will be disconnected and the motor will be stopped at the required trim adjustment. On releasing the centre push-switch, the energizing supplies to relays 360, 361 and 362 will be disconnected, thus reverting the contacts to connect the field circuits of their respective motors to earth.

## AIR BRAKES

154. The air brakes take the form of rectangular flaps secured to moveable drag posts, which in the retracted position, fit into and form part of the upper and lower mainplane surfaces. The system provides for movement of the air brakes outward from the mainplane surface to any of three positions as follows:-

Medium drag – Where the drag posts are

partially extended and the flaps at 35 deg.

High drag — Where the drag posts are almost fully extended and the flaps at 55 deg.

High drag — Where the drag posts are fully extended and the flaps at 80 deg. (alighting gear extended only).

155. Extension or retraction of the air brakes to these positions is effected by an acutator which consists of two motors coupled by a differential reduction gearbox to a common drive shaft. Both motors incorporate solenoid operated brakes which are released whenever a supply is connected to the motor. Reversing contactors enable the motors to be rotated in either direction. Under normal conditions, both motors function in tandem to extend the air brakes from in to the initially selected drag position. Further extension and/or retraction will be effected by one motor only, the second being available as a stand-by. Retraction of the air brakes to the in position will reset the circuits for tandem operation on subsequent initial extend selection. Changeover to the stand-by motor is effected by operation of a selector switch.

156. Two time delay units, one in the switching circuit of each motor, are calibrated to different intervals. The delay is necessary to allow sufficient time for the motor brakes to function when rapid reversal of movement is being employed during flight refuelling operations. The differing intervals prevent the starting loads of both motors being applied to a common supply source simultaneously should generating conditions be other than normal.

157. Transformer-rectifier units are included, one in the supply circuit of each motor. These units provide a d.c. supply to the coil of the brake solenoid. Power factor correction is effected by capacitor units in the supply circuits of each motor.

158. The following text gives details of the electrical components and circuit operation of the air brakes installation. The mechanical system is described in Sect.3, Chap.4 of this publication.

**Control switches**

159. Normal or emergency operation of the motors is provided by a double-pole switch Type D5506 located adjacent to the engine control pedestal at the pilots' station. The switch is labelled AIR BRAKES - NORMAL - EMERGENCY and selection of the emergency position causes changeover to the stand-by motor. Selective positioning of the air brakes is effected by two linked, three position switches, forming an assembly HSA Type 1/V6268 which also embodies a lamp for cockpit lighting purposes. The switch assembly is fitted to the engine control pedestal and is labelled AIR BRAKES-IN-MEDIUM DRAG-HIGH DRAG. The link bar is provided with a locking device which, unless tripped, limits operation of the switches from the in to the medium position. Depression of the plunger in the centre of the bar will trip the locking device, permitting free operation of the switches for other selections. Extension of the air brakes to the high drag 80 deg. landing position is effected by a relay, the energising supply to which is fed via contacts of the nose wheel down micro switch when the nose wheel is extended.

160. The label on the position selector switch also carries the following warning which is applicable during ground servicing operations:-

**WARNING . . .**
**Not to be operated when bomb doors are open and bomb door hinge flaps are in the fully opened position.**

A guard is provided to prevent inadvertent operation of the switch toggles and also provides the locating holes for a locking pin employed during servicing operations. Use of the pin is described in the relevant portion of the servicing text at the end of this chapter.

**Micro switches**

161. Ten Dowmic micro switches, Ref. No.5CW/4742, are fitted, six to the port and four to the starboard brake mechanisms. They are operated by cams and rollers to limit movement of the air brakes to the selected position. The location of the switches is shown in fig.12 and their sequence of operation is given in fig.28.

**Test switch**

162. A single-pole switch, Ref. No. 5CW/4323, is mounted on a panel (V9360) located on the forward starboard side of the nose wheel bay. The switch is labelled AIR BRAKE GROUND TEST - $55^{O}$ - ON, and is spring-return to the centre position. Operation of this switch for functional checking is described in para.269.

**Warning indicator**

163. A magnetic indicator, Ref. No. 5CZ/5074, is installed on the pilots' centre panel and labelled AIR BRAKE. This indicator is energised to show black when the air brakes are at the in position. It is de-energised to show white when the air brakes are extended from the IN position.

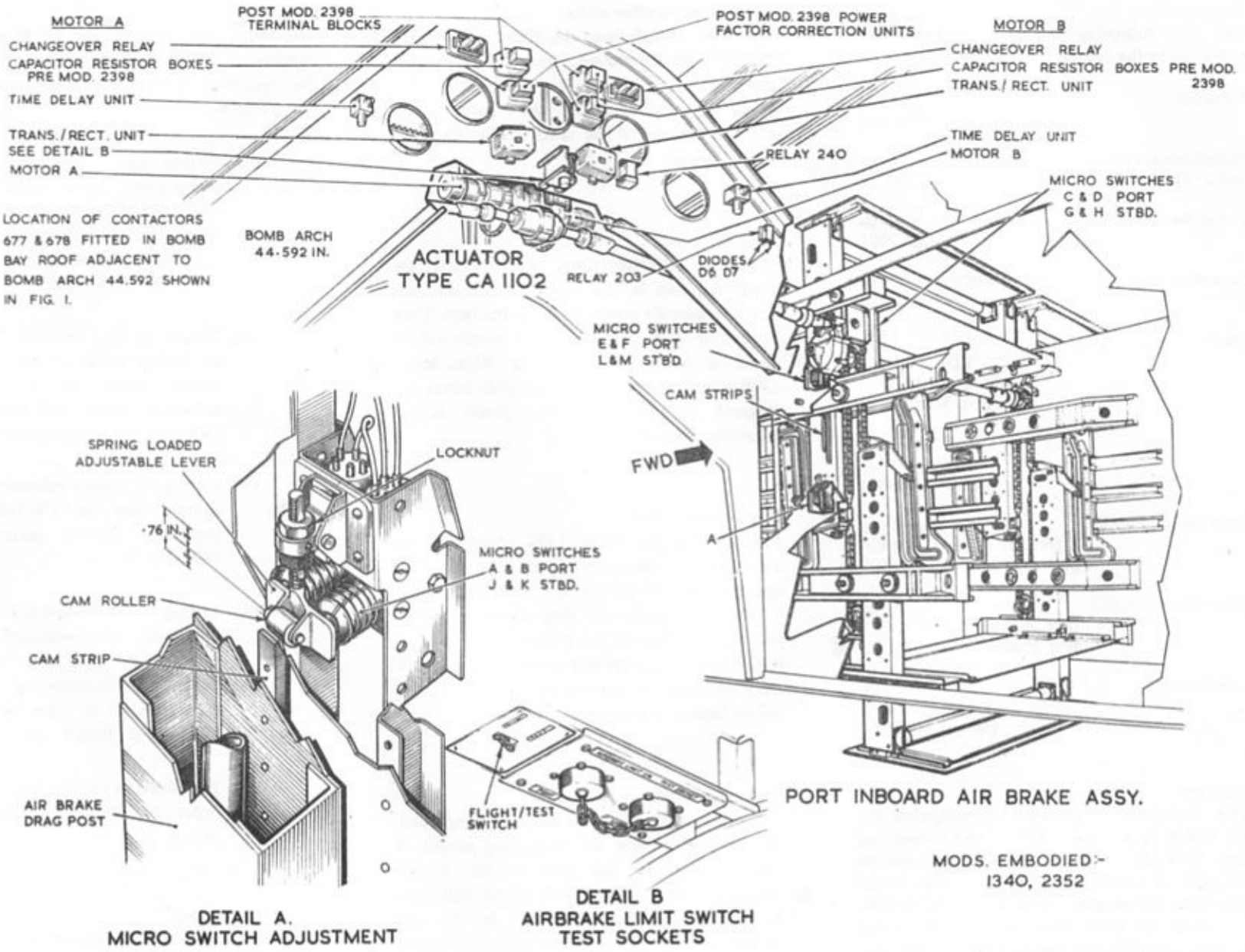



Fig. 12 Air brakes components (Pre and Post Mod. 2398)

► Mod. state clarified ◄

**Components**

164. The following major components are employed in the system:-

| | |
|---|---|
| Actuator | Type CA1102 |
| Transformer-rectifier units (2) | Type U5201/1 |
| Capacitor units (4) pre Mod.2398 | Type ZA7801 |
| Capacitor units (2) post Mod.2398 | Type LP224 |
| Change-over relays (2) | Type LDK 35 Y1/1 (pre Mod.1383 and post Mod.2304) |
| | Type LDK 35 Y3/2 (post Mod.1383) |
| ▶ Time delay unit (1) | B.Ae Type (pre Mod.2451 1/V9303 (post Mod.2451) 30/V9303 |
| Time delay unit (1) | B.Ae. Type (pre Mod.2451) 19/V9303 (post Mod.2451) 34/V9303 ◀ |
| Contactors(2) | Type LDG 100Y/10 (Mod.1340 only) |

*Actuator*

165. The actuator provided to manipulate the air brakes is a Type CA1102 and consists of two 200-volt, 3-phase, 400 Hz a.c. motors coupled to a differential gearbox. One motor functions for normal operation of the system, the other to assist movement of the initial extend selection and thereafter as a standby. They are designated A and B respectively in the illustrations and descriptive text for the installation. Further details of the actuator will be found in the A.P.113 series.

*Transformer rectifier units*

166. Two transformer rectifier units Type U5201/1 are employed, one in the supply circuit of each motor, to provide the d.c. supply for operation of the motor brake solenoid. Details of the units will be found in A.P.113 series.

*Capacitor units*

167. Four capacitor units Type ZA7801, are employed, two in the supply circuit of each motor to provide power factor correction. They are described in para.20, further details will be ▶ found in A.P.113F-0700 series. When Mod. ◀ 2398 is embodied the four capacitor boxes are replaced by two capacitor power factor correction units Type LP224.

*Change-over relays*

168. Two relays, Type LDK (para.164) are used, one in each motor circuit. The relays are operated by the 28-volt d.c. switching circuit of the installation and their contacts control the a.c. supplies to the motors. Operation of the relay interchanges two phases of the supply, thus reversing the motors to extend or retract the air brakes as required.

*Time delay units*

169. Two time delay units are employed, one in the 28-volt d.c. switching circuit of each motor. In the case of the normal ▶ operation motor 'A', this is a unit calibrated to give a delay of 0.25 sec. In the case of the standby motor 'B' the unit is calibrated ◀ to give a delay of 1.05 sec. A circuit diagram of these units is provided at fig.15, and a description of their operation at para.198.

**Mod.1340**

170. With the embodiment of Mod.1340 a number of features are introduced to improve the operation of the air brakes circuit. These are as follows:-

(1) Fitting two 100 amp., 3-phase contactors. Type LDG.100Y/10 (Ref. No. 5CW/6760) to take the high starting currents previously taken by the existing 35 amp. reversing contactors.

(2) Replacing the existing 2-position air brakes indicator on the pilots' centre panel by a 3-position indicator, which will indicate the failure of a main contactor.

(3) Fitting of Dowty microseal micro- ▶ switches (Ref. No. 5CW/1084481) in ◀ place of Dowty microswitches (Ref. No. 5CW/4742).

(4) Fitting two additional Dowty microseal microswitches on the starboard side to prevent assymetric functioning of the air brakes in the event of mechanical failure on one side.

(5) Introduction of two test sockets in order to detect a faulty micro-switch.

*Warning indicator*

171. The indications presented by the 3-position indicator, Dowty Type C5175Y Mk.163, are as follows:-

(1) Black — Air brakes 'in'

(2) White – Air brakes 'out'

(3) Crosshatch – Air brakes failure

**Supplies**

172. 28-volt d.c. supplies are fed to the air brake switching system from fuses in panels 3P and 4P, details of fuse numbering will be found in Chap.6. The 200-volt, 3-phase a.c. supplies are fed to the motor circuits from fuses in panel 60P in the case of motor A and panel 59P for motor B. Details of fuse numbering will be found in Chap.3.

**Mod.2316**

173. This modification introduces an AIR-BRAKE ISOLATE EMERGENCY switch at the top face of panel 3P. The switch enables the AEO to isolate the airbrake motor B in the event of No.1 and No.3 alternator failure. With motor B isolated, the load on the A.A.P.P. is reduced and motor A only is used to operate the airbrakes.

**Mod.2352**

173A. This modification introduces a relay No.835 and seven diodes, D1 to D7 respectively into the circuit to prevent spurious indication of the air brake system. Diodes D1 and D2 are fitted to a mounting plate attached to relay 835 at the external fire protection relay panel 2J. Diode D5 is mounted below relay 835. Diodes D6 and D7 are fitted to a mounting plate attached to relay 203 at the bomb arch (fig.12) and diodes D3 and D4 are fitted to a panel mounted above microswitches J and K.

**Flight-test switch**

173B This modification also introduces a single pole switch labelled FLIGHT-TEST, fitted adjacent to the air brake limit switch test sockets (fig.12) which is used when carrying out functional checks on the microswitches (para.271).

*NOTE . . .*
*Under normal conditions the switch must be wire-locked to the FLIGHT position.*

**Mod.2467**

173C. This modification introduces a diode D8 to prevent a voltage feed, originating from the airbrake indication circuit, between the port and starboard non-essential busbars on failure of the starboard non-essential supply contactor.

174. The following airbrake circuit operation should be read in conjunction with the theoretical circuit diagram provided, Fig.14.

175. The circuit is shown with the air brakes at the 'in' position with no supplies connected to the aircraft. With the aircraft on the ground the contacts of the nose wheel down microswitch will be closed, and when a 28-volt d.c. supply is connected to the aircraft, the following circuit action will take place:-

(1) A supply is fed from fuse 640 via contacts 2-3 of the isolation switch, contacts 4-3 of the control switch, contacts 5-6 of microswitch B and relay contacts 678/3 and 677/2 to energize relay 835. Contacts 835/1 close, connecting the supply from fuse 640 via flight/test switch contacts 2-1, diode D3, contacts 6-5 of microswitch K, diode D4, contacts 2-3 of microswitch K, relay contacts 677/3 and 678/2 to energize the 'in' coil of the indicator. An additional supply to the indicator is fed from fuse 551, via contacts 5-6 of the emergency switch, contacts 4-3 of the control switch, diode D8, contacts 2-3 of microswitch K, relay contacts 677/3 and 678/2, and the now closed contacts 835/1. The indicator will show black.

(2) A supply from fuse 619 (Chap.11) is fed via the nose wheel down microswitch contacts 5-6 and contacts 3-2 of the test switch to energize relay 240.

(3) Changeover of contacts 240/4 to 240/3 and 240/2 to 240/1 will connect the high drag selection circuits for 80 deg. operation.

176. When the aircraft becomes airborne and the alighting gear is retracted, the associated

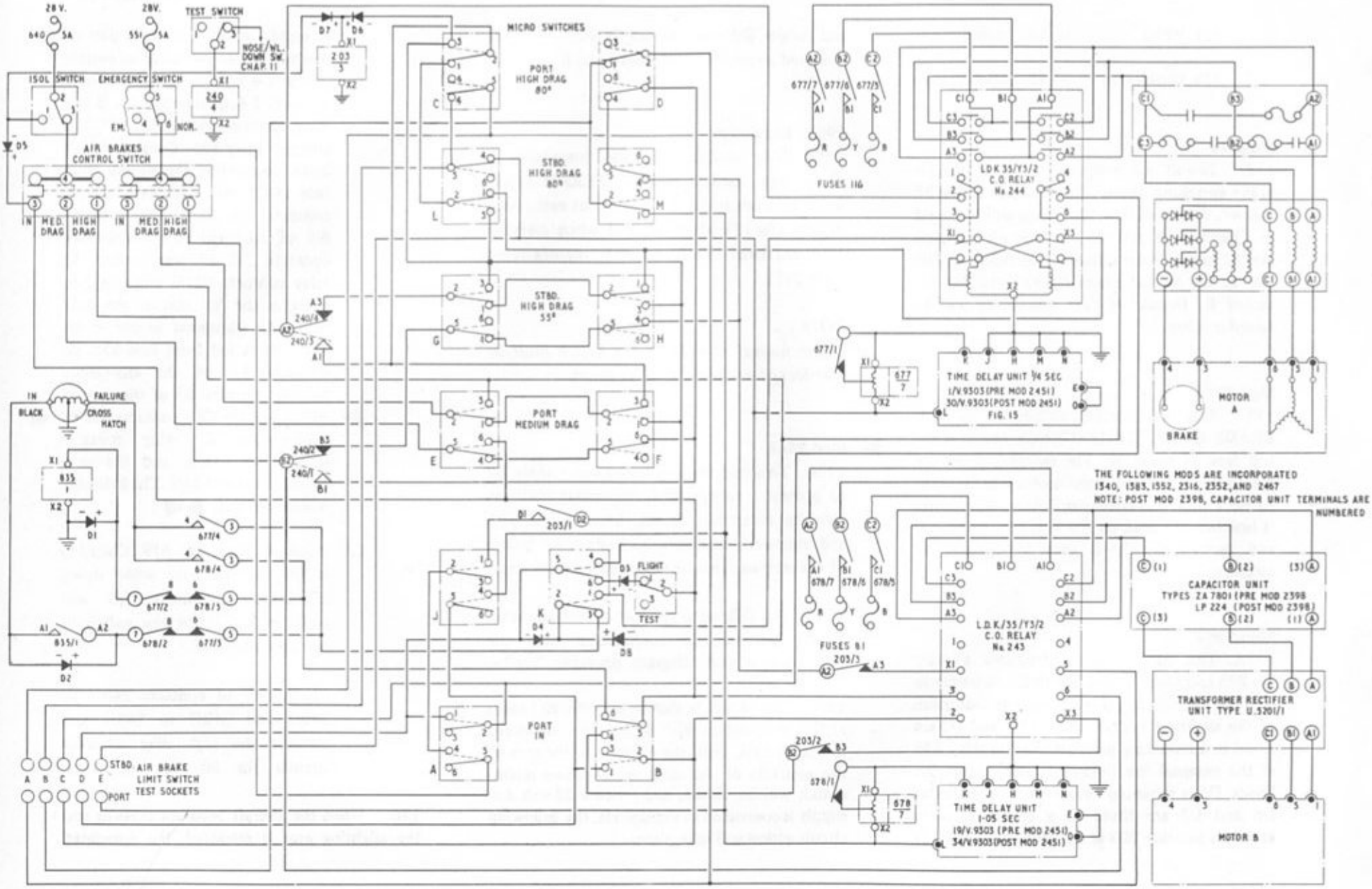



Fig.14 Air brakes control

▶ *Mod 2398, 2451 and 2467* ◀

contacts of the nose wheel down microswitch will open thus de-energizing relay 240. Contacts 240/1 and 240/3 will then return to 240/2 and 240/4 respectively to reconnect the selection circuits for medium and high drag 55 deg. operation.

*In to medium drag*

177. When the control switches are selected to the medium drag position, the following circuit action will take place:-

(1) The supply to the 'in' coil of the indicator will be broken and the indicator will show white.

(2) A supply is fed from fuse 640 via isolation switch contacts 2-3, contacts 4-2 of the control switch, the respective contacts of microswitches E, F, D and M of the normally closed relay contacts 203/3 to the X1 coil of relay 243.

(3) A supply will be fed from fuse 551, via contacts 5-6 of the emergency switch, 4-2 of the control switch and the respective contacts of microswitches E, F, C, L to the X3 coil of relay 244.

(4) The respective coils of relays 243 and 244 as indicated in (2) and (3) will now be energized, and the associated heavy duty contacts will close to prepare the 200-volt a.c. supply circuit to the input terminals 1, 5 and 6 of motor A.

(5) At the same time contacts 243/6-4 and 244/3-1 will changeover to close 243/6-5 and 244/3-2 and the time delay units will be energized via their respective poles L as follows:-

(a) The supply at (2) fed via microswitches E, F, D, M will also continue via contacts 4-5 of microswitches H and G, contacts 240/2, 243/6-5 and contacts 2-1 of microswitches D and M to pin L of the associated time delay unit.

(b) The supply at (3) fed via microswitches E, F, C, L will also continue via contacts 1-2 of microswitches H and G, contacts 240/4, 244/2-3 and contacts 5-4 of microswitches C and L to pin L of the associated time delay unit.

178. Operation of the time delay units (para. 179) will energize relays 677 and 678 and supplies of 200-volt a.c. will be connected as follows:-

(1) From fuses 116 R, Y, B via contacts 677/7, 6 and 5 respectively to terminals 1, 5, 6 of motor A.

(2) From fuses 81 R, Y, B via contacts 678/7, 6 and 5 respectively to terminals 1, 5, 6 of motor B.

At the same time contacts 677/2 and 3, and 678/2 and 3 will open to isolate the 'in' coil of the indicator, and 677/4 and 678/4 will close to prepare a circuit to the 'fail' coil. Resulting from the circuit action at (1) and (2), both motors will commence to move the air brakes from the 'in' to the 'medium drag' 35 deg. position.

179. As the air brakes move out, microswitches A, B, J, K will be operated and their contacts will changeover to connect the circuit for the retract operation medium to in as follows:-

(1) Microswitch A contacts 2-3 to 2-1 and K contacts 5-6 to 5-4 prepare the circuit to the time delay unit (with relay 677).

(2) Microswitch B contacts 2-3 to 2-1 and J contacts 5-6 to 5-4 prepare the circuit to the time delay unit (with relay 678).

(3) Microswitch B contacts 5-6 to 5-4 prepare the circuit to the X3 coil of relay 243, via contacts 203/2.

(4) Microswitch K contacts 2-3 to 2-1 prepare the circuit to the X1 coil of relay 244.

(5) Microswitch A contacts 5-6 to 5-4 and J contacts 2-3 to 2-1 prepare a hold-in supply for relay 203 via normally open contacts 203/1.

180. As the air brakes reach the medium drag position, microswitch F will be operated and the changeover of contacts 5-6 to 5-4 and 2-3 to 2-1 will:-

(1) Disconnect the supplies to relays 243 (X1 coil) and 244 (X3 coil), which will be de-energized.

Resultant opening of the heavy duty contacts will disconnect the a.c. supplies to the motors which will stop. Also the opening of contacts 6-5 (relay 243) and 3-2 (relay 244) will break the supplies to the time delay units and relays 677 and 678 will be de-energized.

(2) Connect a supply from fuse 551, via contacts 5-6 of the emergency switch, 4-2 of the control switch and 2-1 of microswitches E and F, to the coil of relay 203, which will be energized. Contacts 203/1 will then close to complete the hold-in supply to relay 203 as at para.179 (5), and contacts 203/2 and 203/3 will open to isolate relay 243 and its associated supply circuit to motor B from further action under normal conditions.

*Medium to high drag 55 deg.*

181. Selection of the control switch to HIGH DRAG will cause the following circuit action:-

(1) A supply will be fed from fuse 551, via the emergency switch contacts 5-6, control switch contacts 4-1, relay contacts 240/4 and contacts 2-1 of microswitch G and H to the X3 coil of relay 244, which will be energized to prepare the supply circuit to motor A.

(2) Changeover of relay 244 contacts 3-1 to 3-2 will connect the supply from fuse 551 via contacts 5-4 of microswitches C and L to pin L of the time delay unit, which will operate to energize relay 677. A 200-volt, 3-phase, a.c. supply will then be connected from fuses 116 to motor A, which will extend the air brakes from the medium to the high drag 55 deg. position.

182. As the air brakes move from the medium drag position, microswitch E will be operated and changeover of contacts 2-1 to 2-3 and 5-4 to 5-6 will connect the circuit for retract operation high to medium. Note that although the initial supply to relay 203 is now broken, it will remain energized via its hold-in contacts 203/1.

183. As the air brakes reach the high drag 55 deg. position, microswitches G and H will be operated to result in the following:-

(1) Changeover of contacts 2-1 to 2-3 will disconnect the supply to the X3 coil of relay 244, which will be de-energized. This action will cause motor A to stop and, at the same time, de-energize relay 677. In addition, the hold-in supply to the coil of relay 203 is supplemented by a supply via contacts 240/4.

(2) Changeover of contacts 5-4 to 5-6 will break the supply to the open contacts 203/3.

*High drag 55 deg. to 80 deg.*

184. With the control switch at the high drag 55 deg. position, extension of the alighting gear to the landing position will cause relay 240 to be energized via the test switch, and the circuit action will be as follows:-

(1) Changeover of contacts 240/2 to 240/1 will reconnect a supply to the open contacts 203/3 from fuse 640 via contacts 5-4 of microswitches D and M.

(2) Changeover of contacts 240/4 to 240/3 will connect a supply from fuse 551 via the emergency contacts 5-6, the control switch contacts 4-1, relay contacts 240/3 and contacts 2-1 of microswitches C and L to the X3 coil of relay 244, which will be energized.

(3) Circuit action as described in para.181 (2) will result in motor A extending the air brakes from the high drag 55 deg. to the high drag 80 deg. position.

185. As the air brakes reach the 80 deg. position, microswitches C, D, L and M will be operated to result as follows:-

(1) Changeover of the respective contacts of microswitches D and M will disconnect supplies to relay contacts 203/3 and the associated time delay unit.

(2) Changeover of the respective contacts of microswitches C and L will de-energize the X3 coil of relay 244, when motor A will stop and relay 677 will be de-energized as previously described. Also an additional supply to the coil of relay 203 will be connected.

186. The contact arms of all the microswitches will now be in the dotted position. It

should be noted that operation of the control switches from HIGH DRAG to MEDIUM DRAG will cause the same circuit action to retract the air brakes from the 80 deg. or 55 deg. positions.

*High drag 80/55 deg. to medium*

187. Selection of the control switch from HIGH DRAG to MEDIUM DRAG will cause the following circuit action:-

(1) A supply will be fed from fuse 551 via the respective contacts of the emergency and control switches, contacts 2-3 of microswitch E and 2-1 of microswitch K to the X1 coil of relay 244, which will be energized.

(2) Changeover of relay 244 contacts 6-4 to 6-5 will connect the same supply via contacts 2-1 of microswitch A and 5-4 of microswitch K to the time delay unit, which will operate to energize relay 677.

(3) Motor A will then be energized as before except that connection of phases R and B from fuses 116 are interchanged at the contacts of relay 244. The rotation of motor A will thus be reversed causing the air brakes to retract from the high drag 80 or 55 deg. position to the medium drag position.

188. As the air brakes retract from the high drag positions, microswitches C, D, L, M will be operated (leaving high drag 80 deg.) and G, H (leaving high drag 55 deg.) and their contact arms will revert to the normal position in both circuits in readiness for extend operation.

189. As the air brakes move to the medium position, microswitch E will be operated to result as follows:-

(1) Changeover of contacts 2-3 to 2-1 will disconnect the supply to the X1 coil of relay 244, which will be de-energized to stop the motor. At the same time relay 677 will be de-energized.

(2) Changeover of contacts 5-6 to 5-4 will prepare a circuit to contacts 5-6 (still open) of microswitch F.

*Medium drag to 'in'*

190. Selection of the control switch from medium drag to in will now cause the following circuit action:-

(1) A supply will be fed from fuse 551 via the emergency switch contacts 5-6, control switch contacts 4-3, and 2-1 of microswitch K to the X1 coil of relay 244, which will be energized.

(2) Circuit operation as at para.169 (2) and (3) will then result in retraction of the air brakes from medium drag to in.

191. When the air brakes commence to move inwards from medium drag, microswitch F will be operated to prepare the circuit for extend operation.

192. As the air brakes move to the in position, microswitches A, B, J and K will be operated and the following action will result:-

(1) Changeover of microswitch K contacts 2-1 to 2-3 will break the supply to the X1 coil of relay 244, which will be de-energized to stop the motor.

(2) Changeover of microswitch A contacts 2-1 to 2-3 and K contacts 5-4 to 5-6 will de-energize the time delay unit and relay 677.

(3) Changeover of microswitch A contacts 5-4 to 5-6 and J contacts 2-1 to 2-3 will break the hold-in supply to the coil of relay 203, which will be de-energized. Thus the closing of relay contacts 203/2 will prepare the circuit for tandem operation when the next selection to extend the air brakes is made.

(4) Changeover of microswitch B contacts 5-4 to 5-6, and K contacts 2-1 to 2-3 will connect a paralleled supply to the in coil of the indicator, which will show black.

193. The contact arms of all microswitches will now be in their normal positions, and all relays will be de-energized except 240 which will be de-energized when the 28-volt supplies are switched off (also see para.269).

**Air brake isolation switch (Post Mod.2316 and 2352)**

194. In the event of No.1 and No.2 alternator failure, electrical supplies for the air brake system are routed from the A.A.P.P. (Chap.5). Reference to fig.14 shows that when the AIR BRAKE ISOLATE/EMERGENCY switch

is set to ISOLATE, a supply from fuse 640 is fed via contacts 2-1 of the isolation switch, and diode D7 to energise relay 203. Contacts 203/1 will close and contacts 203/2 and 203/3 will open isolating the supply to motor B. The supply to the indicating circuit is maintained by a supply from fuse 640 fed via isolation switch contacts 2-1 and diode D5 to contact 3 of the control switch (Refer to para.175 (1)). With the switch in the ISOLATE position, the electrical load on the A.A.P.P. is reduced and motor A only is used to operate the airbrakes.

**Emergency operation**

195. Should a failure occur in the circuit of motor A subsequent to initial movement of the airbrakes during extension as described in para.177-179, selection of the emergency switch to EMERGENCY will disconnect the supply from fuse 551 to the circuit of motor A, which will be isolated. Also the hold-in supply to the coil of relay 203 (para.179-180) will be broken and the relay de-energised. The AIRBRAKE ISOLATE EMERGENCY switch is set from ISOLATE to NORMAL to provide a supply from fuse 640 via closed contacts 203/2 and 203/3 to energise relay 243. Relay 243 main contacts close to provide a supply to motor B which takes over operation of the airbrakes. This applies at any selected position of the control switch should the emergency switches be operated.

196. It should be noted that operation of the X1 or X3 coil of relay 243 causes opposite movement of the airbrakes to that caused by the corresponding coils of relay 244. The coupling of the motor drive shafts via the differential gear box is fully described in Book 1, Sect.3, Chap.4 of this publication.

*(Continued overleaf)*

**TIME DELAY UNITS**

197. The three time delay units, one in the elevator feel circuit (para.70) and two in the airbrakes circuit (para.169) are identical except for the values of capacitors C1 and C2, which, in conjunction with potentiometer R3 determine the period of time delay. The time delay unit internal circuit, which also indicates the capacitor values, is shown in fig.15, and the operation is given in the following paragraphs.

**Circuit operation**

198. Reference to fig.15 will show that when a 28-volt d.c. supply is connected to pin L of the unit, the following circuit action will take place. The supply will be applied across the series circuit formed by resistor R1 and the

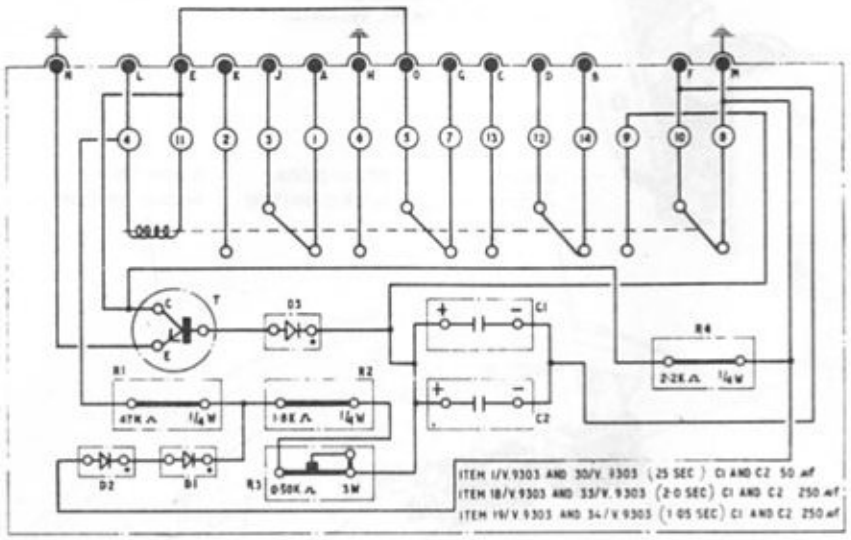



**Fig.15 Time delay unit**
▶ *(Mod 2451)* ◀

two 9-volt Zener diodes D1 and D2. The stabilised 18-volts developed across the diodes will commence to charge capacitors C1 and C2 via series resistor R2 and variable resistor R3, which will have been adjusted to give the required time constant.

199. When the voltage across C1 and C2 rises above 9 volts, diode D3 will conduct and cause base to the emitter current to flow in the circuit formed by the relay coil and the transistor collector, resulting in the coil being energised to operate the contacts. Resistor R4 provides a shunt path for the current in the coil circuit. The closing of contacts 5-6 will complete the hold-in circuit for the relay coil, and closing of contacts 10-9 will short circuit C1 and C2 in readiness for subsequent operation. The closing of contacts 3-2 will connect pin K to pin J.

200. Reference to fig.8 will show that the operation of the time delay unit as described provides a certain measure of control over the artificial feel indication circuits.

201. Reference to fig.14 will show that the operation of the time delay unit will initiate the circuit action outlined in para.178.

### BRAKE PARACHUTE

202. A brake parachute system is installed to provide additional braking facilities should they be required during landing operations. The parachute is stored in a compartment just aft of the fin and is released to the stream or braking position on the opening of the compartment door. This operation is controlled by the pilot who can also jettison the parachute when sufficient additional braking has been effected. The system provides for the automatic jettison of the parachute should the doors inadvertently open. The mechanical aspect of the installation is dealt with in Sect.3, Chap.13 of this publication.

203. Two electrically operated mechanisms are employed, one to open the door and referred to as the 'stream' mechanism, the other to jettison the parachute. Control of the actuators is arranged in two separate circuits each controlling one actuator of each mechanism. This duplication of control and operation causes the actuators of each system to function jointly under normal circuit conditions. For reference purposes the actuators associated with each mechanism have been numbered 1 and 2 in the illustrations and descriptive text for the installation.

204. The relays of the circuits are mounted on a panel, 84P, located on the port side of the E.C.M. bay and adjacent to the parachute compartment.

**Control switches**

205. Two single-pole switches Ref.No. 5CW/5823 are mounted on the inboard edge of the 1st pilot's panel and labelled TAIL PARA-STRM-JETTISON. Simultaneous or separate operation of these switches is provided by a split toggle link. This facility permits operation of one of the switches, should either jam, and independent functional checking of the circuits. The left hand switch controls the No.2 and the right hand switch the No.1 actuator of each mechanism.

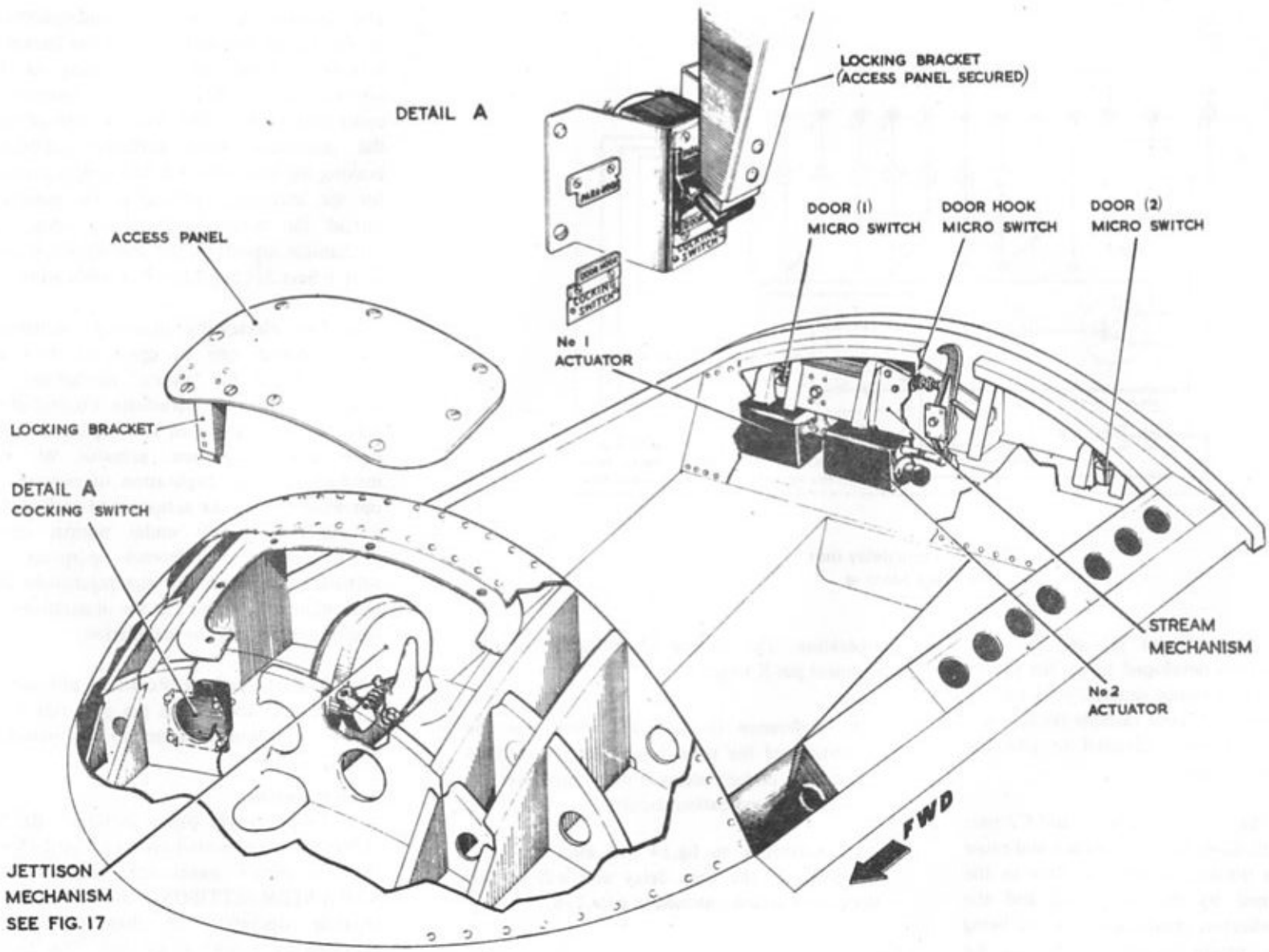



Fig.16 Brake parachute compartment

**Cocking switches**

206. A two-position toggle switch Ref. No.5CW/5824 is installed adjacent to the jettison mechanism and is labelled COCKING SWITCH - DOOR HOOK - PARA. HOOK. The toggle of this switch is secured in the door hook position for normal operation by a bracket attached to an access panel in the forward fairing of the compartment. Removal of this panel allows manipulation of the switch for recocking purposes as described at paras.219 and 223.

**Micro switches**

207. Five micro switches control the operation of the actuators and the indicator circuit. These switches are mechanically operated by various parts of the installation, the types in use being as follows:-

Door (1), Door (2) and Door hook - Honeywell 1EN-N14

Jettison shackle and Jettison hook - Dowmic C1831-Y Mk.9

**Actuators**

208. Four Plessey actuators are employed and are installed in the parachute compartment, two at the aft end for the door release or stream mechanism and two at the forward end mounted as integral parts of the jettison release mechanism. Those for the stream circuits are Type 1CZ/135840/B4 whilst those for the jettison circuits are 1CZ/135840/B5. Further technical details of these actuators will be found in A.P.4343D, Vol.1, Sect.14.

**Indicator**

209. A magnetic indicator Type B2 is provided for ground servicing purposes and is located on the ground servicing intercomm. panel on the starboard outer skin surface of the tail section. The supply circuit to the indicator is controlled by both the door (1) and (2) micro switches and the earth circuit by the door hook micro switch. The indicator is energised to give a black display only when the installation is securely cocked.

**Circuit operation**

210. Referring to fig.18, it should be noted that the circuit is shown with the brake parachute correctly stowed and ready for use, i.e., the door and jettison micro-switches are shown with their associated mechanism in the cocked position and the actuators extended with the retract field selected. The magnetic indicator will be energised black to show this condition when 28-volt d.c. supplies are conneted to fuses 620 and 911, by the following circuit action:-

(1) A supply will be connected from fuse 911, via normally closed relay contacts 650/4, 652/4, 701/1 and the door (2) micro switch terminals 4-6, to the coil of relay 653. The earth circuit will be completed, via terminals 6-4 of the door hook, 5/6 of the jettison hook and jettison shackle micro switches, and the relay will be energised.

(2) Closing of relay contacts 653/1 will connect a supply from fuse 620 via normally closed relay contacts 649/4, 651/4, 700/1 and terminals 1-3 of the door (1) micro switch to the magnetic indicator. The earth circuit of the indicator will be completed as for the relay at (1) and it will be energised to give a black display.

211. The primary function of relays 700 and 701 is to prevent inadvertent jettisoning of the parachute in the event of malfunctioning of either control switch or circuit. They also facilitate the independent functional checking of the circuits. The contacts of these relays are therefore included in the circuit of the switch opposite to that which controls the supply to the coil of their respective relays.

*Stream*

212. Normal manipulation of the control switches will cause simultaneous operation of both circuits. For the purpose of the following description however, the circuit action affecting the No.1 actuators only is dealt with, including the indicator circuit, that for the No.2 actuators being similar.

213. When the stream position is selected supplies will be connected from fuses 620 and 911, via terminals 1-2 of the respective switch to energise the coils of relays 701, 651, 652 and 700. The following circuit action will then take place:-

(1) Changeover of relay contacts 651/4 to 651/3, will transfer the supply at fuse 620, from the indicator to the retract field of the stream (1) actuator. The indicator will be de-energised to give a white display.

(2) Changeover of relay contacts 651/2 to 651/1 will transfer the earth connection, from the jettison (1) actuator circuit, to complete

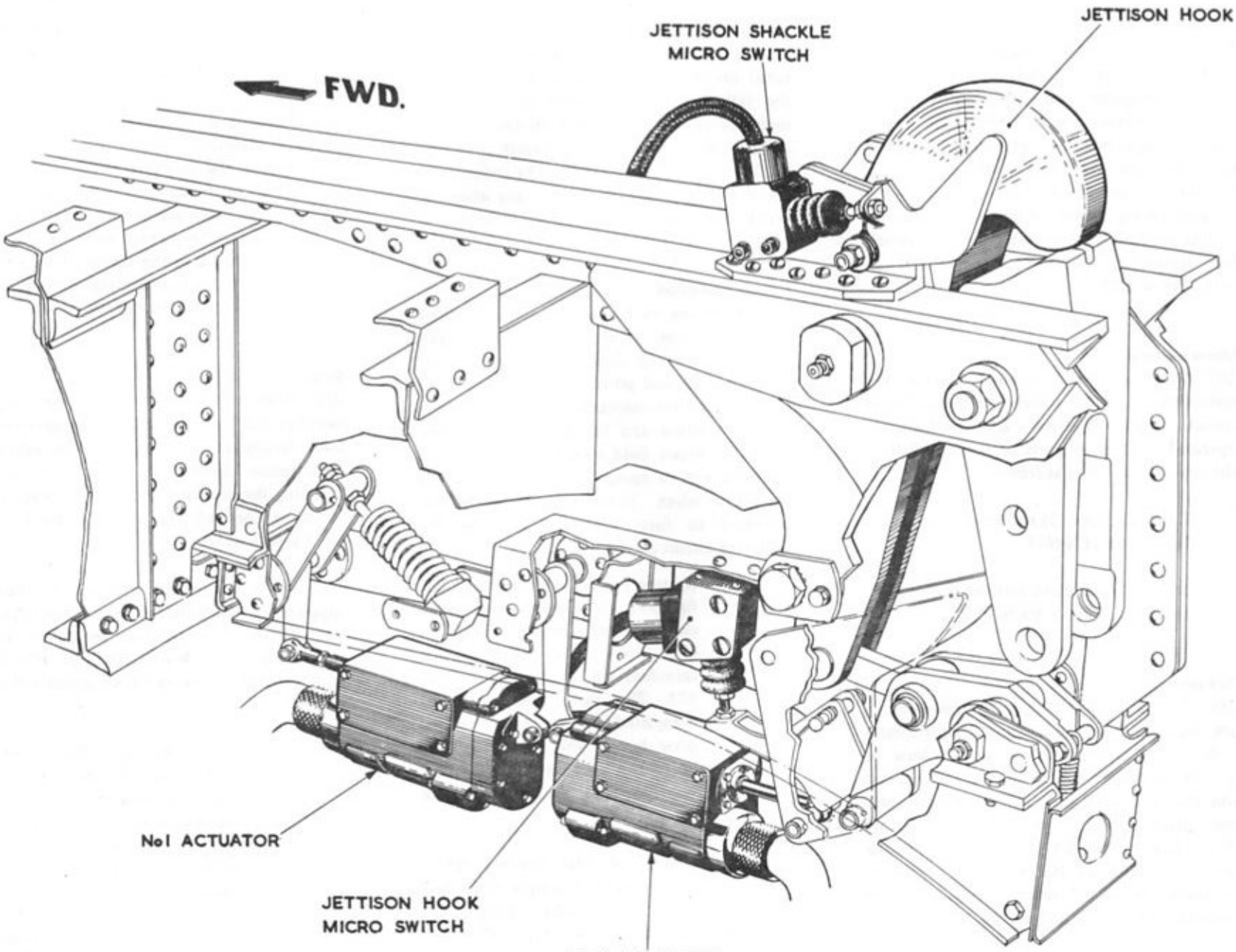



Fig.17 Brake parachute jettison mechanism

the earth circuit of the stream (1) actuator. The actuator will run to the retract position, operating the door hook to allow the doors to open and the parachute will be released to the stream or braking position.

(3) Opening of normally closed relay contacts 700/1 will disconnect terminal 1 of the door (1) micro switch from the supply circuit.

(4) Changeover of relay contacts 652/4 to 652/3 and opening of normally closed relay contacts 701/1, will disconnect the supply from fuse 911 to the coil of relay 653 which will become de-energised.

(5) Opening of relay contacts 653/1 will isolate the magnetic indicator from the supply circuit.

When the stream (1) actuator runs to the fully retracted position as at (2), above, operation of the internal limit switches will stop its movement at that point, the extend field will then be connected in readiness for recocking operations.

214. Operation of the door hook and opening of the doors will cause manipulation of the door hook and door (1) micro switches resulting in the following circuit action:-

(1) Door hook switch

(a) Connection of terminals 1-2 will cause a supply to be fed from fuse 620 to terminal 1 of the jettison hook micro switch in readiness for re-cocking.

(b) Disconnection of terminals 4-6 will interrupt the earth circuits of the indicator and relay 653.

(2) Door (1) switch

(a) Connection of terminals 1-2 will place the retract field circuit of the jettison (1) actuators at readiness for operation.

(b) Disconnection of terminals 4-6 will interrupt the stream recocking circuit.

Manipulation of the door (2) micro switch will place the retract field circuit of the jettison (2) actuator at readiness for operation. The installation will then be set for selection of the jettison position at the control switches.

*Jettison*

215. Operation of the control switches to the jettison position will disconnect the supplies from fuses 620 and 911 to the coils of relays 701, 651, 652 and 700 which will be de-energised. The following circuit action will then take place:-

(1) Changeover of relay contacts 651/3 to 651/4 will transfer the supply at fuse 620 from the retract field of the stream (1) actuator, to the retract field of the jettison (1) actuator, via normally closed contacts 700/1 and terminal 1-2 of the door (1) micro switch.

(2) Changeover of relay contacts 651/1 to 651/2 will transfer the earth connection from the stream (1) actuator circuit to complete the earth circuit of the jettison (1) actuator. The actuator will run to the retract position, operating the jettison hook and detaching the parachute from the aircraft.

When the actuator runs to the fully retracted position as at (2) above, operation of the internal limit switch will stop its movement at that point and select the extend field in readiness for re-cocking.

216. Operation of the jettison hook to release the parachute will cause manipulation of the jettison hook and jettison shackle micro switches resulting in the following circuit action:-

(1) Jettison hook switch

(a) Connection of terminals 1-2 will cause a supply to be fed from fuse 620, via terminals 1-2 of the door hook switch to terminal 1 of the cocking switch in readiness for re-cocking.

(b) Disconnection of terminals 5-6 will further interrupt the earth circuits of the indicator and relay 653.

(2) Jettison shackle switch

(a) Disconnection of terminals

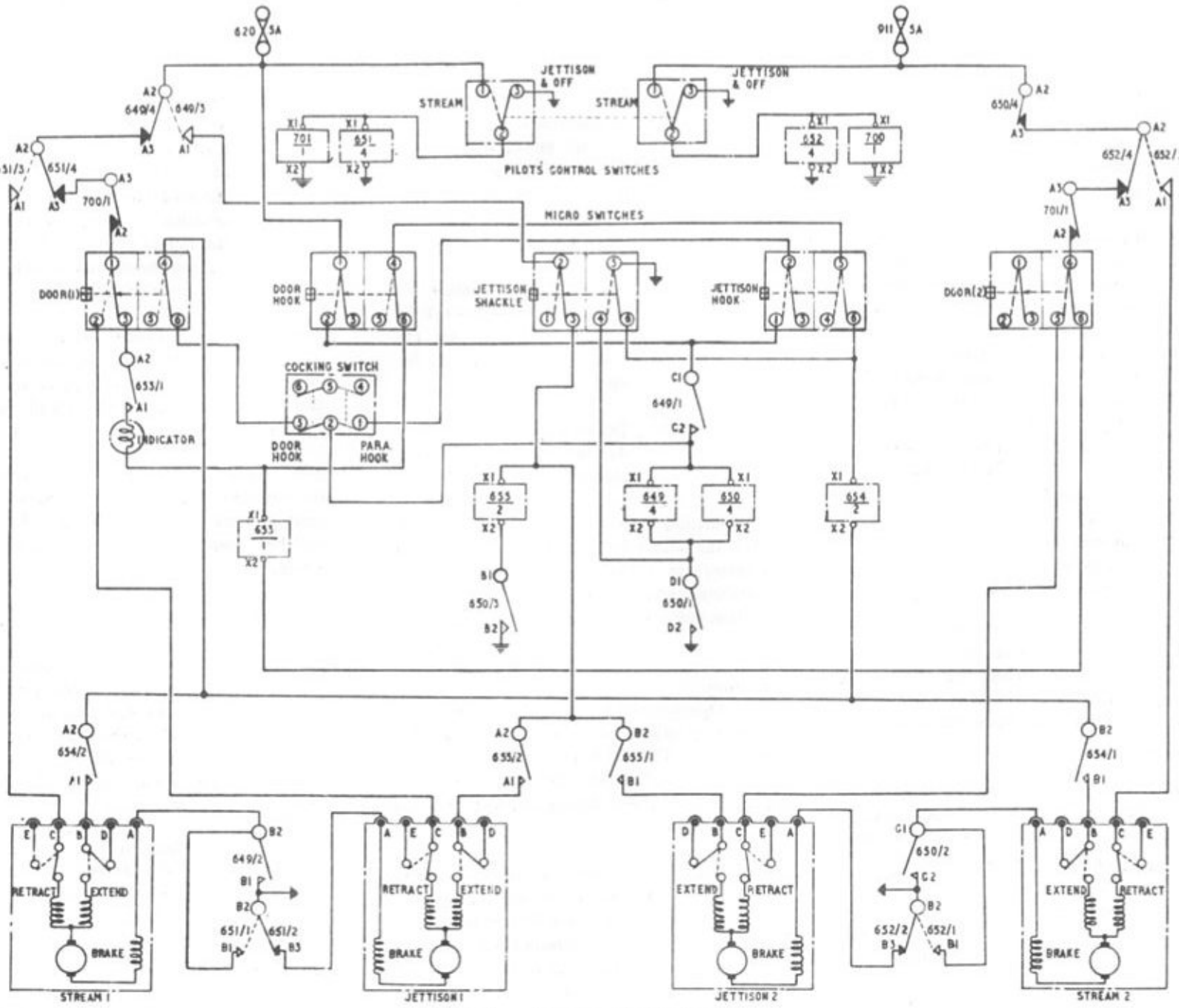



Fig.18 Brake parachute control

2-3 will interrupt the supply circuit from fuse 620 to the re-cocking relay 655 and the re-cocking circuit.

(b) Disconnection of terminal 5-6 will disconnect the earth from the circuit of the indicator and relays 653 and 654.

(c) Connection of terminals 5-4 will complete the earth circuits of relays 649 and 650 in readiness for re-cocking.

The contact arms of all the microswitches will be in the dotted position and the cocking switch in the position of door hook selected.

*Automatic jettison*

217. Referring again to fig.18, it will be seen that should the door of the compartment inadvertently open, the resulting manipulation of the door (1) micro switch will cause the following circuit action:-

(1) Disconnection of terminals 1-3 will interrupt the supply from fuse 620, via relay contacts 649/4, 651/4, 700/1 and 653/1, to the magnetic indicator. The indicator will be de-energised to give a white display.

(2) Connection of terminals 1-2 will transfer the supply at (1) to the retract field of the jettison (1) actuator which will run to the retract position, operating the jettison hook and detaching the parachute from the aeroplane.

The simultaneous manipulation of the door (2) micro swtich, will de-energise relay 653 and cause the jettison (2) actuator to run in tandem with the jettison (1) actuator operation at (2) above, opening of relay contacts 653/1 will additionally interrupt the supply circuit to the magnetic indicator.

218. The circuit operation for automatic jettison will therefore leave the stream actuators at the extended or cocked position. All the micro-switches except the door hook switch will be at the dotted position. Subsequent selection of the stream position at the control switches will cause the normal operation of the actuators as described at para.213. The door hook switch will then be operated to the dotted position. When the control switches are returned to the jettison off position the circuit will be reverted to the post normal operation condition.

**Re-cocking**

219. With the control switches in the off position, re-cocking operations commence with selection of the para. hook position at the cocking switch, when a supply will be fed from fuse 620, via terminals 1-2 of the door hook, jettison hook and cocking switches, to the coils of relays 649 and 650. The earth circuits will be completed via terminals 4-5 of the jettison shackle switch, the relays will be energised and the following circuit action will result:-

(1) Closing of relay contacts 649/1 and 650/1 will, respectively, complete a hold-in supply from fuse 620 via the door hook switch terminals 1-2, and an earth circuit, to the coils of relays 649 and 650.

(2) Closing of relay contacts 649/2 will complete the earth circuit of the stream (1) actuator.

(3) Changeover of relay contacts 649/4 to 649/3 will transfer the supply at fuse 620 to terminal 2 of the jettison shackle micro switch.

(4) Closing of relay contacts 650/3 will complete the earth circuit of relay 655.

(5) Opening of relay contacts 650/4 will isolate the supply at fuse 911 from the operating circuits of the No.2 actuators.

*Jettison*

220. The next operation is the insertion of the parachute shackle in the jettison hook and when this is carried out manipulation of the shackle micro switch will cause the following circuit action:-

(1) Connection of terminals 2-3 will complete a supply from fuse 620 via relay contacts 649/3 to the coil of relay 655, the earth circuit will be made as at para.219(4) and the relay will be energised.

(2) Closing of relay contacts 655/2 will further connect the supply at (1) to the extend field of the jettison (1) actuator. The earth circuit will be completed via normally closed relay contacts 651/2 and the actuator will run to

the extend or cocked position closing the hook. Movement of the actuator will be stopped by operation of the internal limit switches.

(3) Connection of terminals 5-6 will complete the earth circuit of relay 654 in readiness for stream re-cocking.

221. Should it be found necessary at this stage, for any reason, to re-open the jettison hook this can be achieved by first selecting the door hook position at the cocking switch. Momentarily depressing the door hook micro switch will then cause both actuators to run to the retract position opening the hook. Cocking operations can then be re-commenced as at para.219.

222. When the actuators run to the extend position as at para.220.(2), the jettison hook micro switch will be manipulated resulting in the following circuit action:-

(1) Disconnection of terminals 1-2 will remove the supply from fuse 620 to terminals1 of the cocking switch.

(2) Connection of terminals 5-6 will further connect the earth at para.220 (3) to terminal 4 of the door hook switch.

The parachute will now be securely attached to the aeroplane and correctly housed in its stowage.

*Stream*

223. In preparation for re-cocking the stream mechanism the door hook position at the cocking switch should now be selected. When this occurs the following circuit action will result:-

(1) Disconnection of terminals 1-2 will interrupt the initial supply circuit to the coils of relays 649 and 650.

(2) Connection of terminals 2-3 will cause the hold-in supply at para.219 (1) to be fed also to terminal 6 of the door (1) micro switch.

224. The next operation will be to close the compartment door and when this is carried out manipulation of the door (1) and door (2) micro switches will result in the following circuit action:-

(1) Door (1)

(a) Disconnection of terminals 1-2 will interrupt the supply circuit to the retract field of the jettison (1) actuator.

(b) Connection of terminals 1-3 will place the indicator circuit at readiness for operation.

(c) Connection of terminals 4-6 will further connect the supply at para.223 (2) to the coil of relay 654. The earth circuit will be completed via terminals 6-5 of the jettison shackle micro switch and the relay will be energised.

(d) Closing of relay contacts 654/2 will connect the supply at (c) also to the extend field of the stream (1) actuator. The earth circuit will be completed via relay contacts 649/2 and the actuator will move to the extend or cocked position operating the door hook to secure the door.

(2) Door (2)

(a) Disconnection of terminals 4-5 will interrupt the supply circuit to the retract field of the jettison (2) actuator.

(b) Connection of terminals 4-6 will prepare a supply from fuse 911, via normally closed relay contacts 650/4, 652/4 and 701/1 to the coil of relay 653.

225. When the door hook is operated to secure the door, the hook micro switch will be manipulated resulting in the following circuit action:-

(1) Disconnection of terminals 1-2 will:-

(a) Remove the hold-in supply from fuse 620 via relay contacts 649/1 to the coils of relays 649 and 650, which will be de-energised.

(b) Remove the supply from fuse 620 to the coil of relay 654, as at para.224 (1) (c), and the relay will be de-energised.

(2) Opening of relay contacts 649/1 and 650/1 will interrupt the hold-in circuit to the coils of both their relays.

(3) Opening of relay contacts 649/2 will isolate the field circuits of the stream (1) actuator from earth.

(4) Changeover of relay contacts 649/3 to 649/4 will transfer the supply at fuse 620, via relay contacts 651/4, 700/1 and terminals 1-3 of the door (1) micro switch to relay contacts 653/1 in readiness to operate the indicator.

(5) Opening of relay contacts 650/3 will isolate relay 655 from earth.

(6) Closing of relay contacts 650/4 will connect a supply from fuse 911, via relay contacts 652/4, 701/1 and terminals 4-6 of the door (2) switch to the coil of relay 653.

(7) Connection of terminals 4-6 of the door hook switch will complete the earth circuit of relay 653, via terminals 5-6 of the jettison hook and shackle switches, and the relay will be energised.

(8) Closing of relay contacts 653/1 will complete the supply at para.(4) to the indicator, which will be energised black indicating that re-cocking operations have been correctly completed.

## SERVICING

### Introduction

226. Due to the nature of the flying control system, it is essential that the closest co-operation is maintained between the airframe, electrical and instrument trades during servicing operations. This will minimise the repetition of functional and calibration checks. The following paragraphs contain servicing information for the electrical circuits and components of the flying control systems. Mechanical Servicing details for the system are given in Sect.3, Chap.4 of this publication.

## POWER FLYING CONTROLS

227. The wiring to the P.F.C. motors and control gear should be examined periodically for general security and cleanliness. Particular attention should be given to the heavy duty cables between the contactors and the P.F.C. units, to ensure that the connections are tight and the cable insulation is free from damage.

### P.F.C. motors

228. Servicing of the P.F.C. units whilst they are installed in the aircraft consists of routine inspections for security of attachment and functional testing of the individual motors using the miscellaneous systems test console in accordance with the schedule provided in A.P.4343V, Vol.1. Servicing details for the pump units and motors when detached from the aircraft will be found in the appropriate parts of their respective A.P.'s as follows:-

| | |
|---|---|
| Pump units | A.P.4603C, D or E |
| Motors | A.P.4343D |

### P.F.C. contactors

229. The relay contactors employed in the supply circuits of the P.F.C. units are B.T.H. Type LDG35-Y2/1. Servicing instructions for these relays will be found in A.P.4343C, Vol.1.

### Time delay switches

230. Servicing details for these items also will be found in A.P.4343C, Vol.1.

### Functional checks

231. Functional checks on the P.F.C. units can be carried out prior to flying taking place, these checks should be made in the following manner:-

(1) Ensure that both 200-volt a.c. and 28-volt d.c. ground supplies are connected to the aircraft external supply plugs.

(2) Check that all the elevon and rudder P.F.C. red warning lamps at the pilots' console light and that the reminder indicator on the centre instrument panel shows a black image. The main warning lamps on the centre panel will also be lit.

(3) In conjunction with the airframe fitter, ensure that the flying control surfaces on the wings and rudder are clear of any obstruction (ladders, trestles etc.).

(4) Start the three groups of P.F.C. units in turn by depressing the respective start switch at the port

console. Check for correct starting sequence as at para.9, and simultaneously, for extinguishing of the appropriate unit warning lamp.

232. When all the P.F.C. units are started, the reminder indicator will continue to be energised and show black while normal circuit conditions prevail. The main warning lamps, however, will go out. (See Book 3, Sect.7, Chap.6, for connection of main warning lamps to the auto-stabilisation circuits).

233 The powered flying controls can now be functioned by the airframe fitter, and checked for freedom of movement, correct sense etc. as laid down in Sect.3, Chap.4 of this publication. During this check the operation of the rudder auxiliary unit should be proved by pressing the rudder main unit stop/warning switch and ensuring that the rudder controls continue to operate satisfactorily. Servicing instructions for the control surface position indicator are contained in Sect.7, Chap.2 of this publication.

234. When the functional checks have been completed the P.F.C. units should be stopped by momentarily depressing in turn, the stop/warning switches. It should be noted that when these switches are operated to stop the respective unit, this will cause a momentary lighting of the stop switch lamp and blink at the reminder indicator. The continuous lighting of the stop lamp will commence when the pressure has fallen sufficiently to close the lock valve micro switch contacts. This will occur approximately 10 to 12 seconds after depressing the switch.

## ARTIFICIAL FEEL

**WARNING . . .**
**When a 28-volt d.c. supply only is fed to the aircraft system for ground testing the artificial feel systems, operation of the P.F.C. start switches to connect these supplies will simultaneously energise the latched relays in the supply circuits of the P.F.C. units. Subsequent connection of a 200-volt a.c. supply to the aircraft could cause the starting load of all ten P.F.C. units to be imposed on the system simultaneously, resulting in possible damage to the associated equipment and/or injury to servicing personnel. For this reason it is essential that immediately after operation of the P.F.C. start switches these relays should be tripped by operation of the respective stop switches.**

235. Efficient operation of the artificial feel systems depends on correct functioning of the moving coil relays of the electrical circuits. For this reason care should be taken during servicing operations that these relays are not subjected to circuit conditions, other than those for normal operation, for periods longer than absolutely necessary.

### Feel units

236. The artificial feel units, including the micro switches, are accurately adjusted and set by the contractor prior to their installation in the aircraft. The seals on the boxes, therefore must NOT be broken. If an artificial feel unit is suspected of being faulty, it should be returned to the appropriate servicing depot and another serviceable unit fitted in the aircraft.

### *Feel unit calibrator*

237. An artificial feel unit calibrator, U1390 (Ref.No.26D/95217), is available for bench testing the artificial feel units. The calibration checks on the aircraft system when required (para.239-242). Full details of the calibrator and its application will be found in Book 3, Sect.7, Chap.8.

238. To assist in the early detection of possible faults in the artificial feel system, a series of tests are laid down in Book 1, Sect.3, Chap.4 of this publication. These tests will be carried out by the airframe tradesmen, but due to the fact that electrical supplies will be necessary to run the P.F.C. units, and that the tests require the use of a portable manometer, both the electrical and instrument trades will be required during the tests.

### Failure warning system

239. It will be realized from the nature of the artificial feel system on the aircraft, that setting up and calibration tests will be necessary on the failure warning portion of the system. These tests, contained in the following paragraphs must be carried out whenever an artificial feel unit is changed, or any of the components in 66P are changed. The following notes are provided for the guidance of personnel concerned and should be studied carefully prior to commencing any adjustments.

NOTE 1

Damage to the capsules of the airspeed potentiometers can be caused by application of pressures in excess of 500 knots. This can occur as a result of a sticking valve on the ground test apparatus. Such damage usually causes the 'cut-in' and 'cut-out' limits of the system to vary from the required setting.

NOTE 2

Experience has proved that for the purpose of setting up operations, the

graduated scale of the micro ammeter relays in the warning system does not provide a sufficiently accurate zero current indication. For this reason, during such operations, a reliable centre zero reading micro ammeter graduated to 100 micro amp. should be connected in series with the coil of the relay being adjusted. The zero current indication of this instrument should then be used for the setting up adjustments.

NOTE 3

The ideal setting for the warning system is at an airspeed differential of 25 knots above and below that at which a fault occurs and every effort should be made to approach as closely as possible to this figure. The differential should not in any case be allowed to exceed 35 knots. In some cases the decreasing and increasing differentials resulting from a setting at a reference speed may be found to differ. This is of no consequence provided they both fall within the limits of 25 to 35 knots, as the important consideration is that the warning system should not be affected by flight conditions. Very rapid application of the rudder or aileron can cause a blink at the magnetic indicator but does not indicate failure.

*Setting up procedure*

240. The figures of low, middle and high airspeeds given in Table 2 are intended to be used as inspection speeds as the warning system is required to function correctly at all speeds. The setting up procedure for balancing the warning circuit with the feel unit circuit requires that the reference airspeed should be approached from not less than 50 knots below its own value. The initial setting and checking procedure for the differential requires that the reference airspeed should be approached from not less than 50 knots above and below its own value. This is necessary to verify both increasing and decreasing airspeed differentials. Having engaged artificial feel, the figures quoted at Table 2 for the respective system should be employed in conjunction with the following paragraphs.

*Balance*

241.

(1) Set the sensitivity potentiometer, the low speed and the high speed trimmers of the warning system to their approximate mid-positions.

(2) Apply simulated airspeed to both the feel unit and warning system and increase to the low figure.

(3) Adjust the low speed trimmer of the warning system for zero current indication on the micro ammeter (Para.239, Note 2).

(4) Increase the airspeed in both systems to the high figure.

(5) Adjust the high speed trimmer for zero current indication on the micro ammeter.

(6) Reduce airspeed in both systems to at least 50 knots below the low figure and increase again to the low figure.

(7) Re-check adjustment of low speed trimmer for zero current in the micro-ammeter.

(8) Repeat as in (4), (5), (6) and (7) until balance is approximately correct at both high and low speeds.

*Differentials*

242. When carrying out the following checks it should be noted that, in the case of the elevator feel system, operation of the reminder indicator to show white at (3) and (5) below will occur 2 seconds after the required adjustments are made, due to the function of the time delay unit. In order to provide instant indication, therefore, during checks on the elevator feel system, a test lamp should be connected across terminals B-D at T.B.1150 in 66P. The test lamp should light when the correct adjustments at (3) and (5) are made. Note that with Mod.1856 embodied the test lamp should be connected across T.B.1150 terminal B and relay 438-L for the rudder system. After the checks the test lamp should be removed.

(1) From not less than 50 knots below the mid figure increase the airspeed in both systems to the mid-figure.

(2) Keeping the feel unit airspeed constant introduce a 25 knot differential by carefully raising the warning airspeed.

(3) Adjust the sensitivity potentiometer of the warning system until the magnetic indicator is de-energised to give a white display. It may be found necessary to slightly increase the airspeed differential in order to cause this to occur. Note airspeed differential at which it does.

(4) Increase airspeed in both systems to not less than 50 knots above mid speed then decrease the airspeed in both to mid speed. The indicator should now show black.

(5) Keeping the feel unit airspeed constant, further decrease the warning system airspeed until the magnetic indicator shows white and note at what differential this occurs.

(6) Compare the high and low differentials, these should fall within the limits of 25 knots to 35 knots or 21 to 31 knots when Mod.2206 is embodied.

(7) Re-check the balance as in para.241 if necessary. If adjustment is necessary repeat as in para.242 (1) to (6).

(8) Increase and decrease airspeed between 0 and 460 knots at a rate of approximately 500 per minute. No warning signal should be given during this test. If a signal is given slight trimmer adjustment is required.

*Checking differentials*

243. A check of the settings may be made using the low airspeed for reference in the case of the decreasing differential and the high airspeed for reference in the case of the increasing differential.

*Autopilot control*

244. Instructions for setting No.1, 2 and 3 potentiometers pre and post Mod.1856 will be found in Book 3, Sect. 7, Chap. 6 and 9 respectively.

**Fault finding**

245. Having synchronised the warning circuit in accordance with the foregoing procedure the feel system should not require a great deal of attention. The feel unit however is subject to servicing by the manufacturers only and the following information may be of use to personnel concerned in checking the overall feel system for correct functioning.

*Micro switch settings*

246. The two micro switches employed in the elevator sense and rudder feel units are correctly adjusted on the initial assembly of the unit. These should require little attention and their initial settings should not vary sufficiently to cause malfunctioning. The correct operation of these switches can be checked in the following manner.

247. Provided no 28-volt d.c. supply has been connected to the aircraft since disconnection after previous use, proceed as follows:-

(1) Connect a 28-volt d.c. supply to the aircraft system, the short high pitched hum of the elevator sense and rudder relief actuators as they move automatically to the relief position will be heard.

(2) Check that the three individual and two main warning lamps are lit and that the reminder indicator shows a white display.

(3) Check that the pointers of the micro ammeter relays of the three systems, on the feel units and warning system are all indicating neutral.

(4) Engage artificial feel for the respective system to be checked. In the case of the elevator sense and rudder units the short high pitched hum of the relief actuator moving from the relief to the feel engaged position will be heard.

(5) Check that the individual warning lamp for the system selected only is extinguished. The reminder indicator will be energised black and the main warning lamps will go out when all three feel systems are engaged.

(6) Check that the pointers of the micro ammeter relays in the feel unit and the warning systems move from the neutral position. Movement will be to the low end of the graduated scale on the feel unit instrument and slightly off neutral on the warning instrument. In the case of engaging feel in the aileron sense system movement of the actuator will not take place until cut-in speed is exceeded.

248. It should be noted that for airspeeds up to the cut-in speed for the control surface in the case of the elevator sense and rudder units, the ravel of the relief actuator between the relief and engaged positions is very short. The reason for this is that up to the cut-in speed, the lever mechanism will be in the position of

minimum restriction of movement due to airspeed variation. The feel actuator will have been stopped at that point by the opening contacts of its internal limit switch in the extend field circuit. The mechanism will therefore have only a short travel left to the position of fixed minimum restriction of movement i.e., not subject to airspeed variation or feel relieved. The adjustment of the external limit switch in the retract field circuit of the relief actuator is made to cause the motor to stop at this point.

249. With feel engaged in the case of all three systems, increasing airspeed up to the approx. cut-in speed will cause no variation in the indications or circuit operation. As cut-in speed is exceeded the pointers of the feel unit relays will move through the neutral to the high end of the scale, where closing of the high relay contacts will result in progressive movement of the actuator according to the respective system. The pointers of the warning relays will neutralise as feel is adjusted in step with airspeed variation.

250. On increasing airspeed beyond cut-out but not in excess of 500 knots, the micro ammeter relays of the rudder and aileron sense feel units will indicate to the high end of the graduated scale. This is due to the adjustment of the lever mechanisms; the setting of the internal limit switches in the relief actuator and motor prevent further movement. In the case of the elevator sense unit, on increasing airspeed beyond cut-out the pointer of the feel unit relay will indicate just off neutral to the high end of the scale.

251. During the few seconds required by the feel unit to attain its final adjustment to an airspeed setting a loud ticking sound will be heard. This is caused by operation of relays and the actuator brakes and is quite in order.

*Aileron 2nd limit switch*

252. The 2nd limit micro switch for the aileron feel unit (Mod.1806) is set with the aileron feel actuator fully extended and the switch plunger touching the striker pin on the feel unit lever, so that further extension of the actuator by 0.018 in. to 0.026 in. would operate the switch. This setting can be verified by connecting a battery test lamp across T.B.1325, terminals D-E, and inserting a plate of 24 s.w.g., between the striker pin and the switch plunger. The test lamp should light when the plate is inserted and go out when the plate is removed.

*Feel unit*

253. The warning system compares the potential of the follow-up potentiometer in the feel unit with that of the airspeed potentiometer in the warning circuit. If the feel unit is working correctly at any given airspeed, the potentials of both the airspeed and follow-up potentiometers will be the same as that of the airspeed potentiometer in the warning circuit. If for any reason there is an electrical fault in the feel unit it will either:-

(1) Remain stationary and not respond to airspeed variation.

(2) Set itself to a speed condition above or below the actual airspeed.

(3) Operate to the high speed condition and remain there.

254. The effect will depend on the nature of the fault. For any of these faults, the warning system will indicate within 30 knots of the fault occurring. For this purpose the warning system has to be very sensitive and it is so sensitive that it may indicate a feel unit failure when none exists. This is generally caused by the incorrect setting of the warning panel trimmers which should really be balanced, but according to the characteristics of the airspeed transmitters, may have to be biased slightly. This is more fully explained in the section of A.F.U. warning system.

255. If a pilot reports that his warning indicator has been flickering during flight, before the feel unit is replaced the warning system should be fully checked and tested in accordance with paras.240 and 241. If the warning panel micro-relay is very close to making a contact either on the low or high positions when tested on the ground, it may well be in flight that there are other conditions of pressure, temperature, vibration, pipe leaks, yaw etc., which can cause a contact to be made. The warning panel trimmers should be reset to prevent this occurring. It is appreciated that this may be difficult and that success largely depends upon the experience of the operator. Sometimes airspeed transmitters are damaged or develop faults during use which effect the functioning of the feel unit or warning system.

*Airspeed potentiometers*

256. The potentiometers consist of:-

(1) A capsule which expands when pressure from the pitot head is fed to it.

(2) A coil across which 28 volts is applied.

(3) A wiper arm which is moved across the coil by the expansion of the capsule.

The potential on the wiper arm varies therefore, according to the airspeed. Sometimes a wiper arm will not respond smoothly to variations of airspeed and moves erratically. This can cause a fault indication to be shown. The fault may be either in the feel unit or on 58P. Another fault which can develop is that the wiper arm may lose contact with the coil. If the feel unit potentiometer is at fault then this will be indicated to the pilot, but normally this is overcome with a change of airspeed which brings the wiper back into contact with the coil. If one end of the coil breaks, or if a lead to the coil breaks, the feel rate moves to either a maximum or minimum, according to which end of the coil is effected. The pilot will of course receive warning.

*Follow-up potentiometer*

257. The follow-up potentiometer consists of a single coil and a wiper arm operated mechanically by a cam in the feel unit. The faults which normally occur are very similar to those in the airspeed potentiometers.

(1) Breaking of coil or lead to coil, causing maximum or minimum feel rate.

(2) Bad contact of wiper coil causing hunting.

(3) Wiper arm losing contact with coil in this case the feel rate remains constant at the speed at which the fault occurred.

If the motion of the follow-up potentiometer becomes excessively stiff, the feel unit will respond correctly to increasing airspeed but, when speed is reduced, the feel will run down to the minimum feel position and will remain there until the speed at which the fault occurred is exceeded.

*Components box*

258. Dry joints developing in the wiring of the components box can cause the introduction of an extraneous resistance in the circuit. The symptoms of this occuring will be movement of the feel mechanism in excess of the correct amount for either increasing or decreasing airspeed. The system will then function to correct the over-movement resulting in a form of hunting in its operation. Failure of any of the capacitors will cause arcing at the contacts of the moving coil relay. This will cause sluggish breaking of the contacts and result in excessive movement which will again be corrected as for the dry joint conditions above. The moving coil relays employed in the boxes are Sangamo-Weston Type S54-1-285, experience has proved these items to be very reliable under normal operating conditions. Where servicing operations of any kind are found necessary in the components box care must be taken not to upset the calibrated settings of the sensitivity and trimmer potentiometers.

## TRIM SYSTEM

259. Little servicing is required on the normal and emergency trim controls, apart from routine checks on the wiring and switches for general security and cleanliness.

**Actuators**

260. The two-motor linear actuators of the A1711 and A1708 series should be serviced in accordance with the instructions contained in A.P.113E series. The setting for the travel of the actuators for each system (aileron, elevator and rudder) are given in Sect.3, Chap.4.

**Trim switches**

261. The normal aileron and elevator trim control switches, fitted on the pilots' control handles, should be checked for correct operation during the trim system functional test (para.262). No servicing is permissible on the switches, and an unserviceable switch must be removed and replaced with a serviceable item of the correct type. The normal rudder trim switch located on the fuel gauge panel (2P), should also be checked for correct operation (para.263). The emergency trim switch, Type TS104 Mk.14, should be checked for correct operation in each axis during the trim system functional check (para.264). Any suspect switch must be replaced by a serviceable item of the correct type.

**Functional checks**

262. A functional check of the normal and emergency trim systems should be carried out preferably at the same time as the P.F.C. units are checked (para.231). The checks must be done in conjunction with the airframe tradesman so that the sense and range checks laid down in Sect.3, Chap.4, can be done at the same time. Procedure is as follows:-

(1) Start up the powered flying control units, as given in para.231.

(2) Select normal aileron trim using the first pilot's trim switch, check for correct operation and travel.

(3) Select normal elevator trim using the first pilot's trim switch, check for correct operation and travel.

(4) Repeat (2) and (3) using the second pilot's trim switch.

(5) Select opposite aileron sense trim on each pilot's switch in turn and check that system functions for the first selection only

(6) Repeat (5) for elevator sense trim and check that system functions for the first selection only.

263. The rudder trim system should be checked by operating the two rudder trim switches on the fuel gauge panel 2P. The two switches must be operated together: operation of one switch only will not function the system.

264. The emergency trim circuits should be checked by moving the emergency trim switch knob to each position in turn, with the centre button depressed, and the trim controls checked for correct sense and operation. If selection is made without the centre button depressed the system should not operate.

*NOTE . . .*
*After any functional checks on the trim controls the system must always be left with the surface trimmed to neutral.*

## AIR BRAKES

**WARNING . . .**

**(1) Do not operate the air brakes if the access doors at the forward end of the bomb doors are in the fully open position.**

**(2) During servicing operations, where the drive shaft on either side of the actuator is uncoupled, or any of the micro switches disconnected, the air brakes must be operated by hand and not by the motors.**

265. The wiring of the air brakes circuit should be checked periodically for general security and signs of chafing. Particular attention should be given to the heavy connectors on the contactors and motors portion of the system. The position selector switch guard provides the locating holes for a locking pin H.S.A. Part No. U.2153 (fig.2). This pin can be inserted to secure the toggles of the switches in either the in or the high drag position. It should be employed during servicing operations either in the cockpit or elsewhere to further safeguard against inadvertent operation of the switches.

### Actuator

266. In situ servicing of the air brake actuator is limited to a check for security and brush wear. Further information will be found in A.P.4343D, Vol.1.

### Changeover relays

267. These units should be inspected periodically for undue arcing and burning of the main contacts. Further servicing information will be found in A.P.4343C, Vol.1.

### Micro switch setting

268. Referring to fig.12, it will be seen that the micro switches provided to control movement of the air brakes are operated by spring-return levers to which are attached cam rollers. Manipulation of the rollers is effected by cam strips affixed to the drag posts of the airbrake mechanism. The micro switch assemblies are adjusted on initial fitment so that operation of the respective switch contacts will disconnect the supplies to the actuator motor at a point in the mechanism travel prior to the required position. This occurs during extend or retract movement of the airbrakes and is necessary to allow for override in the mechanism travel. It should be noted that the override will be liable to vary with use. For this reason the position of the rollers relative to the mechanism travel is variable by means of the adjustable securing bolt. Re-adjustment of the roller positions can be carried out using the air brakes test set H.S.A. Type U.1339. The test set provides a means of inching the mechanism to any position in its travel when the correct operation of the respective micro switch contacts can be checked and the roller position adjusted accordingly. Technical details and operating instructions for the test set Type U.1339 will be found in A.P.4343V, Vol.1, Sect.4, Chap.6.

### Test switch

269. The location and other details of this switch are given at para.162. Referring to figs.13 and 14 it will be seen that with the switch in its normal centre position and the aircraft on the ground, a supply will be completed via the nose wheel down micro switch to energise the coil of relay 240. Changeover of normally closed relay contacts 240/4 to 240/3 and 240/2 to 240/1 will select the high drag 80 deg. air brake circuits. Selection of the on position at the switch will interrupt the supply to the coil of relay 240

and return of the relay contacts to their normally closed state 240/4 and 240/2, will then permit functional checking of the high drag 55 deg. circuits as required.

**Test sockets (Mod.1340)**

270. The two test sockets (para.170) are fitted on a bracket above the airbrakes actuator in the bomb bay (fig.12). The sockets one port and one starboard enable the appropriate limit micro switches to be checked for correct operation when the air brakes are (a) fully retracted, and (b) fully extended, i.e., at high drag 80 deg. A suitable battery test lamp should be connected to each socket and the check carried out when required as detailed in para.272.

**Functional checks**

271 Functional checks for the airbrakes, which should be carried out in conjunction with the airframe tradesmen, are contained in Sect.3, Chap.4 of this publication. It is important that the airbrake motors should not be run continuously for more than 3 minutes, after which a 45 minute cooling period must be observed.

◀ **Flight/test switch (Post Mod.2352)**

271A. The FLIGHT/TEST switch located adjacent to the airbrake test sockets (para.173B) must be placed in the TEST position before carrying out the functional checks on the micro switches.

*NOTE . . .*
*After completion of the checks the switch must be wire locked in the FLIGHT position.* ▶

*Micro switch check*

272. Should the operation of a micro switch be suspect at the fully retracted or fully extended (high drag 80 deg.) position of the airbrakes, a check can be made on each of the associated micro switches by connecting a suitable battery test lamp to each test socket and selecting the airbrakes control switch to IN and HIGH DRAG in turn. A circuit to light the lamp should be completed via the respective socket pins and contacts of the micro switch as follows:-

AIR BRAKES IN

| Port socket pins | Micro switch | Lamp |
|---|---|---|
| A-B | D | ON |
| B-E | M | ON |
| E-D | J | OFF |
| D-C | B | OFF |
| Stbd. socket pins | | |
| A-B | C | ON |
| B-E | L | ON |
| E-D | K | OFF |
| D-C | A | OFF |

AIR BRAKES OUT (80 DEG.)

| Port socket pins | Micro switch | Lamp |
|---|---|---|
| A-B | D | OFF |
| B-E | M | OFF |
| E-D | J | ON |
| D-C | B | ON |
| Stbd. socket pins | | |
| A-B | C | OFF |
| B-E | L | OFF |
| E-D | K | ON |
| D-C | A | ON |

**TIME DELAY UNITS**

273. The HS.A. Type V.9303 time delay units are supplied as sealed items. A unit found to be defective should therefore be returned to the manufacturer and replaced by a serviceable item.

**BRAKE PARACHUTE**

274. The installation should be inspected periodically for security of attachment of the components and associated cable connections. A check should also be made for signs of chafing where cable runs are affixed to the aircraft structure adjacent to moving parts.

**Micro switch settings**

275. Setting of the micro switches in relation to the mechanism by which they are manipulated is detailed fully in Sect.3, Chap.13 of this publication. These settings should be checked periodically including at the same time a check to ensure freedom of plunger movement. Simultaneously also operation of the indicator should be checked to ensure that a black indication occurs only when the door is securely closed and locked.

**Actuators**

276. Servicing instructions for the actuators employed in the installation will be found in A.P.4343D, Vol.1, Sect.14.

## PRECAUTIONS

277. Before disconnecting any items of electrical equipment prior to removal it is essential to ensure that the associated electrical circuit is safe. After removal of equipment all loose connectors should be properly insulated and stowed securely. A further check should be made to ensure electrical safety of the circuits prior to reconnection on replacing the equipment. When necessary the appropriate routing chart should be referred to for reconnection details.

### P.F.C. units

278. Removal and assembly instructions for the P.F.C. units are given in detail, along with the necessary illustrations in Chap.4, Sect.3.

### P.F.C. switch panel

279. Access to the switch connections and mountings is obtained by releasing the dzus fasteners securing the inboard cover of the panel. Releasing the two securing screws affixing the attachment bracket to the structure at each end of the panel and removing the connectors will allow the complete panel to be removed.

### Artificial feel units

280. Removal and assembly instructions for the artificial feel units are contained in Sect.3, Chap.4. In the case of the elevator sense and rudder units, additional care in handling the units is necessary as the attached components box contains a moving coil relay.

## REMOVAL AND INSTALLATION

*NOTE . . .*
*With the embodiment of Mod.2075 the artificial feel units are replaced as follows:-*

| | |
|---|---|
| *Aileron:* | *26/R.4188 in lieu of 25/R.4188* |
| *Rudder:* | *18/R.4349 in lieu of 17/R.4349* |
| *Elevator:* | *29/R.4350 in lieu of 27/R.4350 (post Mod.1856)* |
| | *30/R.4350 in lieu of 28/R.4350 (pre Mod.1856)* |

*As the modification involves disturbance of the flying control system, it is essential that an independent check of the control system be made in accordance with A.P.3158, Vol.2, Leaflet B.28.*

### Pilots' control handles

281. Should replacement of the pilots' control handles (Part No. Dunlop AC.61320) be necessary, the correct procedure for this operation is outlined in the following paragraphs. A wiring diagram of the control handles is given in fig.18A, which provides instructions for preparing the ends of the attached cables before new handles are fitted.

282. The method of removing each control handle is as follows:-

(1) Disconnect the control handle wiring at the appropriate T.B.'s behind the pilots' instrument panels.

(2) Unstrap the three cable groups from the existing looms so that they hang freely from the entry to the main control column.

(3) Attach a pull-through cord to the end of one of the cable groups. (The cord will be used to assist passage of the cables when a new handle is fitted).

(4) Apply Hellerine lubricant, Grade C, to the P.V.C. sleeving over the cables to permit easy passage through the main control column.

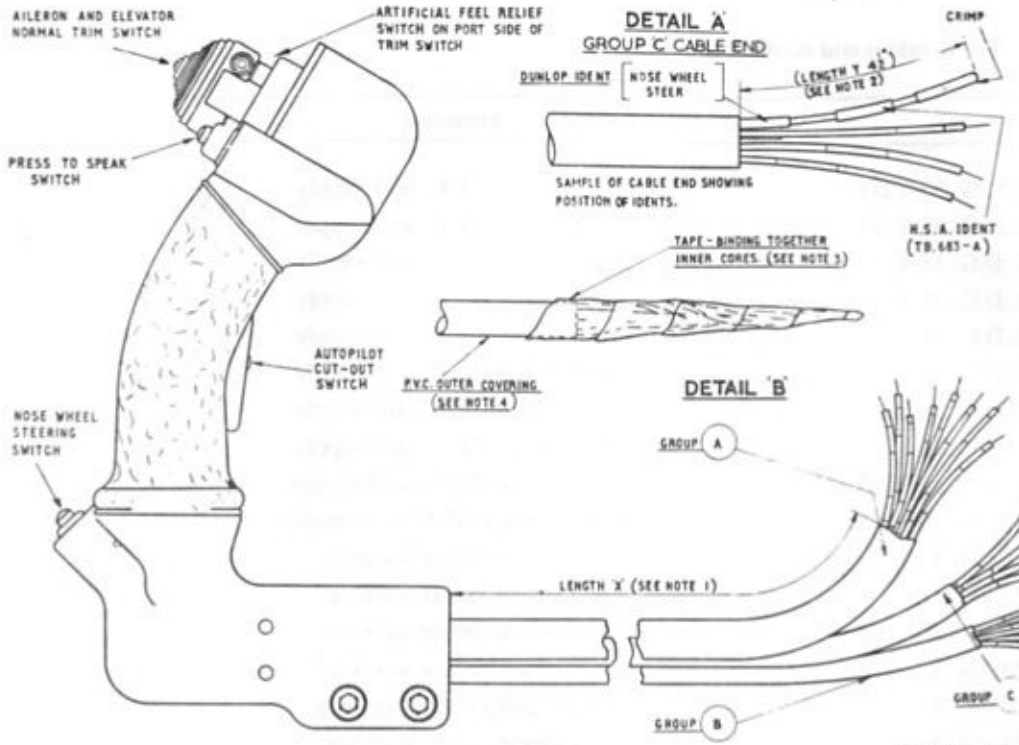
(5) Remove the split pins from the two Allen screws securing the handle to the control column and remove the Allen screws.

(6) Carefully withdraw the handle from the control column, at the same time allowing the cables to be fed through the entry at the other end of the column.

(7) When the cables are clear of the control column untie the pull-through cord.

283. Before a new control handle can be fitted, the attached cables must be cut to the required length and fitted with idents, crimps and P.V.C. sleeving as illustrated in fig.18A. The P.V.C. sleeving is then lubricated as in para.282(4) and the cable ends taped to allow ease of threading through the main control column (see detail B). When the new handle is

being fitted, the pull-through cord should be attached to the ends of the three cable groups, the cables then fed into the control column and guided out at the other end by the cord. The handle is then secured to the control column by the Allen screws and the screws locked with new split pins, the tape and cord removed from the cables, and the cables strapped to the existing looms and connected in accordance with the associated table.




BEFORE ASSEMBLY THE CABLES ARE TO BE CUT TO LENGTH (SEE NOTE 1) AND IDENTED TO AGREE WITH THE TERMINAL BLOCKS TO WHICH THEY ARE CONNECTED ON THE AIRCRAFT SEE FOLLOWING TABLE:-

| IDENTS FITTED ON CABLES SUPPLIED WITH DUNLOP HANDLE PART A C 61320 | CABLE GROUP | IDENTS TO BE ADDED BEFORE ASSEMBLY | | | |
|---|---|---|---|---|---|
| | | PORT | Y | STARBOARD | Y |
| SWITCH 'A' ELEV. TRIM DOWN | A | TB. 683 - D | 4½" | TB. 686 - C | 3¾" |
| SWITCH 'A' ELEV. TRIM UP | A | TB. 684 - C | 3 3/4" | TB. 765 - C | 9" |
| SWITCH 'A' AIL. TRIM STBD. | A | TB. 766 - C | 8½" | TB. 688 - C | 8" |
| SWITCH 'A' AIL. TRIM PORT | A | TB. 683 - E | 4½" | TB. 686 - D | 5½" |
| SWITCH 'B' ELEV. TRIM DOWN | A | TB. 766 - D | 8¾" | TB. 765 - D | 8¾" |
| SWITCH 'B' ELEV. TRIM UP | A | TB. 766 - D | 8¾" | TB. 765 - D | 8¾" |
| SWITCH 'B' AIL. TRIM STBD. | A | TB. 766 - A | 8" | TB. 765 - B | 9" |
| SWITCH 'B' AIL. TRIM PORT | A | TB. 766 - B | 8" | TB. 765 - B | 9" |
| SWITCH 'A' TRIM +VE. | B | TB. 764 - A | 9" | TB. 688 - D | 8½" |
| SWITCH 'B' TRIM +VE. | B | TB. 764 - E | 9½" | TB. 688 - B | 8½" |
| A/P CUT OUT | B | TB. 684 - D | 5½" | TB. 687 - D | 6½" |
| A/P CUT OUT | B | TB. 685 - A | 6½" | TB. 687 - C | 7" |
| ARTIFICIAL FEEL RELIEF | B | TB. 684 - A | 5½" | TB. 687 - A | 7½" |
| ARTIFICIAL FEEL RELIEF | B | TB. 683 - A | 4½" | TB. 686 - B | 6" |
| NOSE WHEEL STEER | C | TB. 683 - A | 4½" | TB. 686 - A | 6¾" |
| NOSE WHEEL STEER | C | TB. 683 - B | 4½" | TB. 686 - B | 6" |
| PRESS TO SPEAK | C | TB. 684 - E | 6½" | TP. 687 - E | 7" |
| PRESS TO SPEAK | C | TB. 684 - B | 5½" | TB. 687 - B | 7½" |

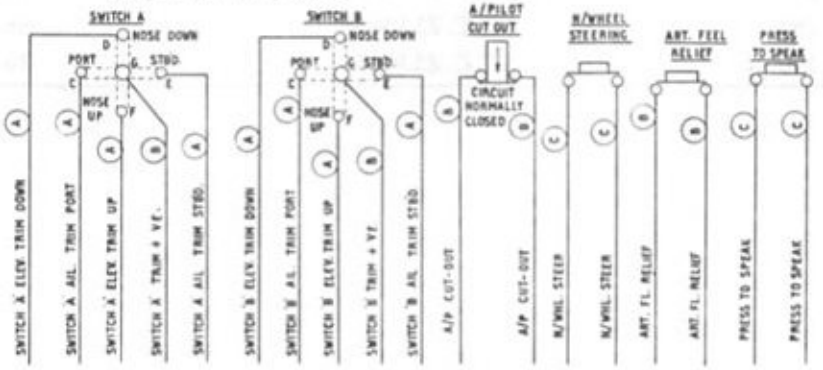
1. P.V.C. OUTER COVERING FOR EACH GROUP HAS TO BE CUT TO LENGTH 5'-3" (LENGTH X SEE MAIN VIEW) CARE BEING TAKEN NOT TO DAMAGE THE INNER CORES. SLIDE DUNLOP IDENTS DOWN EACH CORE UNTIL ADJACENT TO OUTER COVERING. (AS SHOWN IN DETAIL 'A')
2. CUT EACH CORE TO DIMENSION 'Y' AS INDICATED IN TABLE ABOVE SEE DETAIL 'A'. FIT H.S.A. IDENT AND CRIMPS. ALL CRIMPS ARE ITEM 10/V3650.
3. TO FACILITATE FITTING CABLES THROUGH MAIN CONTROL COLUMN TWIST CORES TOGETHER AND BIND WITH MASKING TAPE (SEE DETAIL 'B')
4. P.V.C. OUTER COVERING TO BE SMEARED WITH HELLERINE LUBRICANT GRADE 'C' TO ASSIST THREADING OF CABLE THROUGH CONTROL COLUMN
5. WHERE CABLE INSULATION IS TOO THICK TO ENTER BUCKET OF FERRULE IT IS PERMISSIBLE TO FIT 9/V5650 IN PLACE OF 10/V5650 AS CALLED UP IN NOTE 2. CABLES SUPPLIED WITH HAND GRIP ARE UNIFLEX PREN 6

NOTE:- DUNLOP HANDLE A C 61320 IS SUPPLIED WITH CABLES LEFT LONG AND ENDS ARE ONLY IDENTED THUS:-

| | | |
|---|---|---|
| GROUP A | LEAD | SW. 'A' ELEVATOR TRIM DOWN |
| | | SW. 'A' AILERON TRIM PORT |
| | | SW. 'A' ELEVATOR TRIM UP |
| | | SW. 'A' AILERON TRIM STBD. |
| | | SW. 'B' ELEVATOR TRIM DOWN |
| | | SW. 'B' AILERON TRIM PORT |
| | | SW. 'B' ELEVATOR TRIM UP |
| | | SW. 'B' AILERON TRIM STBD. |
| GROUP B | LEAD | SW. 'A' TRIM +VE |
| | | SW. 'B' TRIM +VE |
| | | A/P CUT OUT - 2 LEADS |
| | | ART. FEEL RELIEF - 2 LEADS |
| GROUP C | LEADS | N/WHEEL STEERING - 2 LEADS |
| | | PRESS TO SPEAK - 2 LEADS |

SWITCH WIRING DIAGRAM

DUAL 4 WAY TRIM SWITCH




(A) THESE INDICATE THE GROUP (B) OF CABLES IN WHICH THE (C) CONNECTOR IS INCLUDED

Fig.18A Pilots' control handles wiring

TABLE 1

P.F.C. relays and contactors

| Relay No. | Type | Function |
|---|---|---|
| 21 | B.T.H. L.D.G. 35-Y2/3 | No.1 elevon P.F.C. unit supply |
| 22 | B.T.H. L.D.G. 35-Y2/3 | No.2 elevon P.F.C. unit supply |
| 23 | B.T.H. L.D.G. 35-Y2/3 | No.3 elevon P.F.C. unit supply |
| 24 | B.T.H. L.D.G. 35-Y2/3 | No.4 elevon P.F.C. unit supply |
| 49 | B.T.H. L.D.G. 35-Y2/3 | No.6 elevon P.F.C. unit supply |
| 50 | B.T.H. L.D.G. 35-Y2/3 | No.7 elevon P.F.C. unit supply |
| 51 | B.T.H. L.D.G. 35-Y2/3 | No.8 elevon P.F.C. unit supply |
| 52 | B.T.G. L.D.G. 35-Y2/3 | No.5 elevon P.F.C. unit supply |
| 53 | B.T.H. L.D.G. 35-Y2/3 | Rudder aux. P.F.C. unit supply |
| 54 | B.T.H. L.D.G. 35-Y2/3 | Rudder main P.F.C. unit supply |
| 281 | S.T.C. Z530473 | No.1 elevon failure warning |
| 282 | S.T.C. Z530473 | No.2 elevon failure warning |
| 283 | S.T.C. Z530473 | No.3 elevon failure warning |
| 284 | S.T.C. Z530473 | No.4 elevon failure warning |
| 285 | S.T.C. Z530473 | Rudder main failure warning |
| 286 | S.T.C. Z530473 | No.5 elevon failure warning |
| 287 | S.T.C. Z530473 | No.6 elevon failure warning |
| 288 | S.T.C. Z530473 | No.7 elevon failure warning |
| 289 | S.T.C. Z530473 | No.8 elevon failure warning |
| 290 | S.T.C. Z530473 | Rudder aux. failure warning |

TABLE 2

Setting speeds (knots) for artificial feel systems

| A.F.U. Cut-in (Approx.) | | Low | Mid | High | Cut-out (Approx.) |
|---|---|---|---|---|---|
| Rudder | 130 | 170 | 295 | 400 | 450 |
| Elevator sense | 90 | 130 | 275 | 400 | 460 |
| Aileron sense | 150 | 190 | 262 | 315 | 370 |

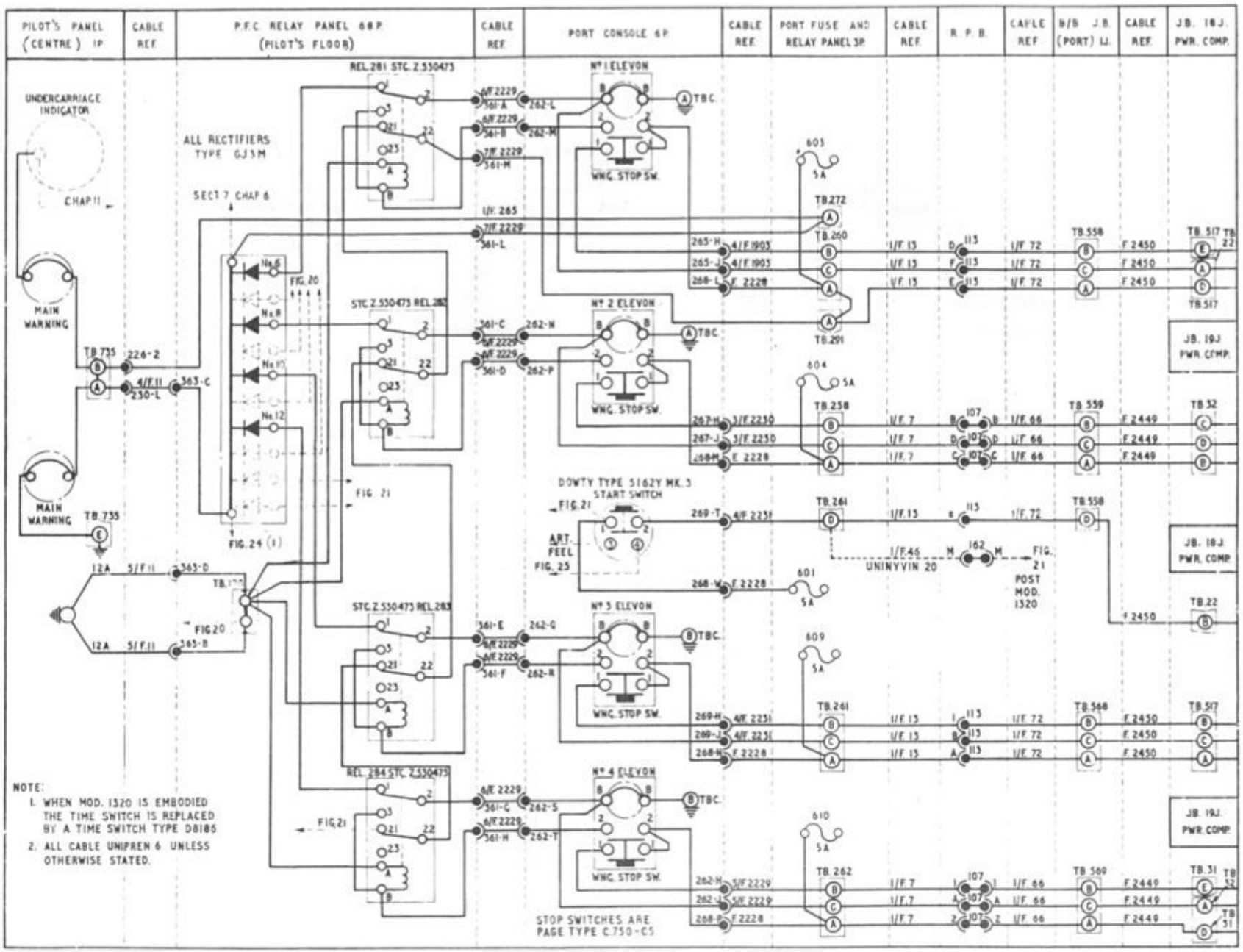



Fig 19(1) No.1,2,3 and 4 elevon P.F.C.'s (pre and post Mod 1320, pre Mod 2398)

◀ Mod. state clarified ▶

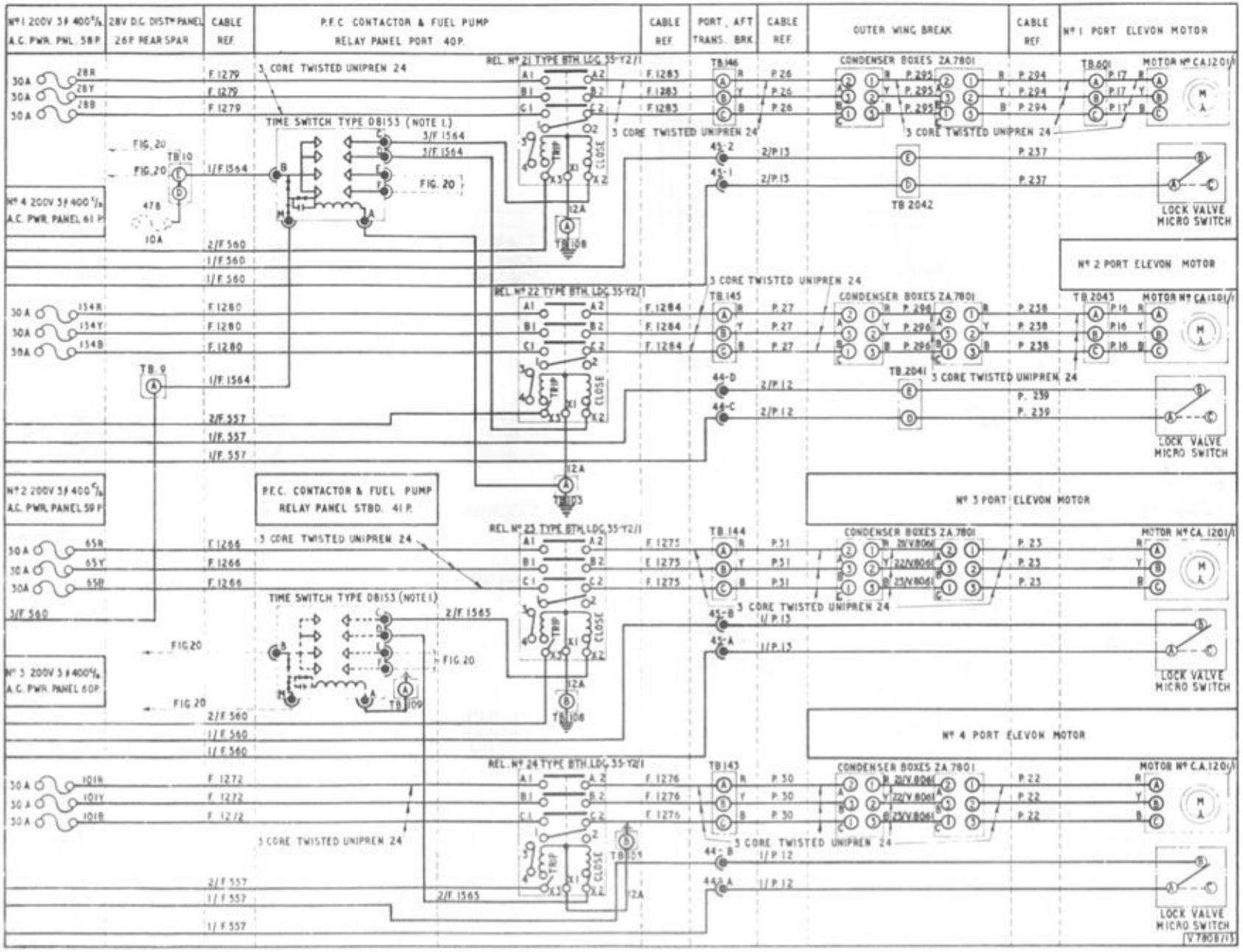



Fig 19 (2) No.1,2,3 and 4 elevon P.F.C.'s (pre and post Mod 1320, pre Mod 2398)

◀ Mod state clarified ▶

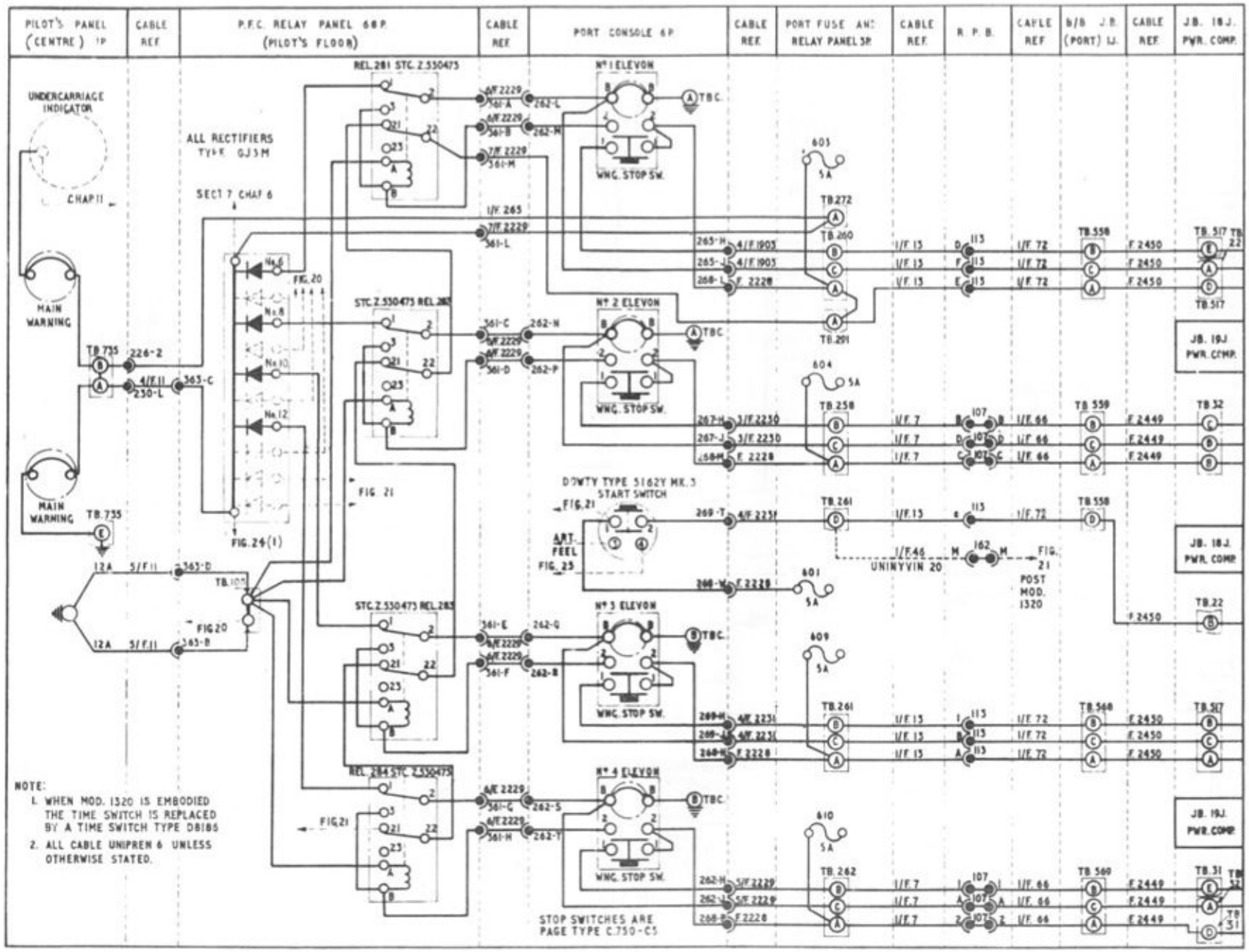



Fig 19A (1) No.1,2,3 and 4 elevon PFC's (pre and post Mod 1320, post Mod 2398)

◀Mod 2398▶

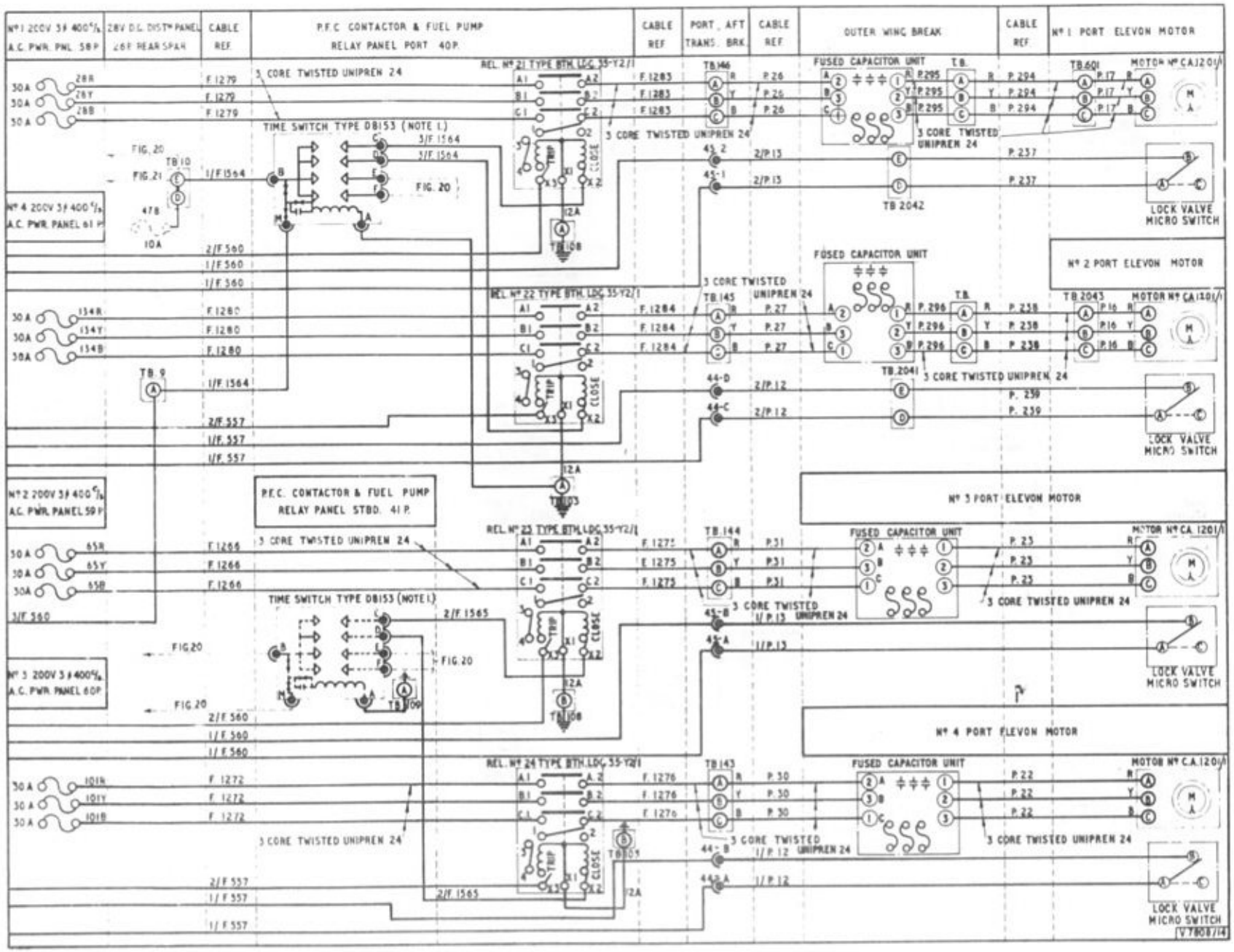



Fig 19A (2) No. 1, 2, 3 and 4 elevon P.F.C's (pre. and post Mod 1320, post Mod 2398)

◀Mod 2398▶

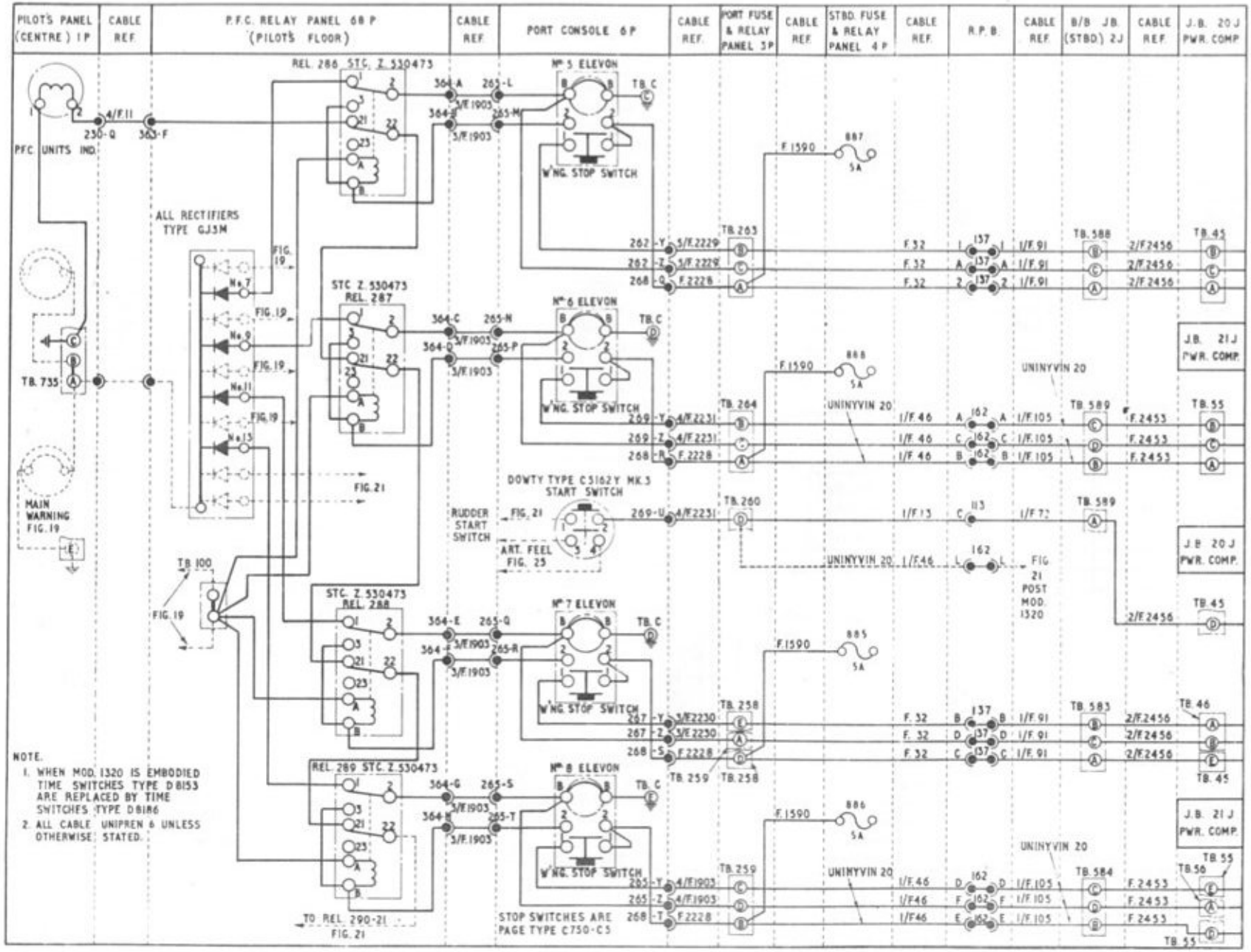



Fig. 20 I No. 5,6,7 and 8 elevon P.F.C.'s pre. and post Mod. 1320, pre. Mod. 2398

◄Mod state clarified►

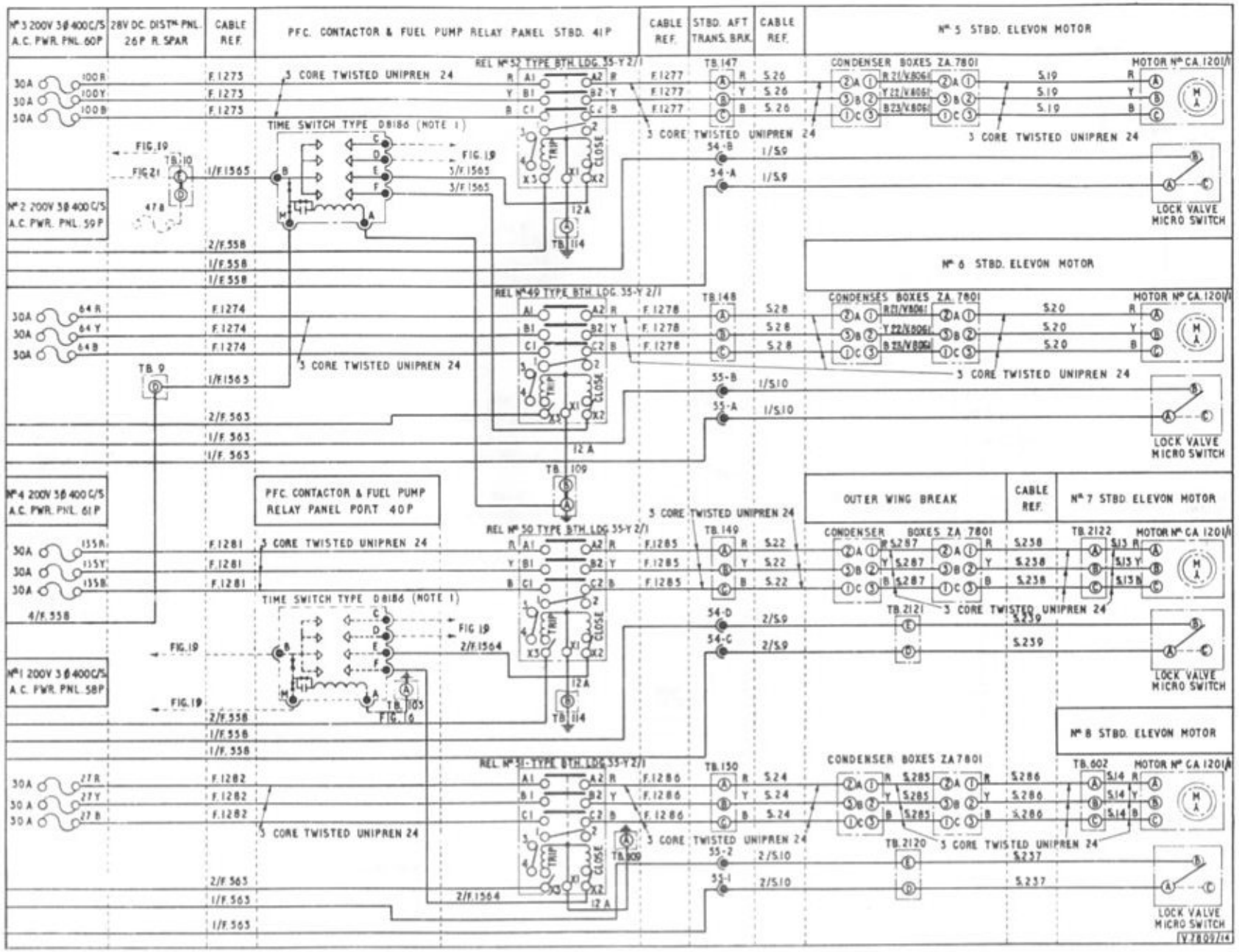



Fig 20.2 No 5,6,7 and 8 elevon P.F.C's (pre and post Mod 1320 pre. Mod. 2398)

◄ Mod state clarified ►

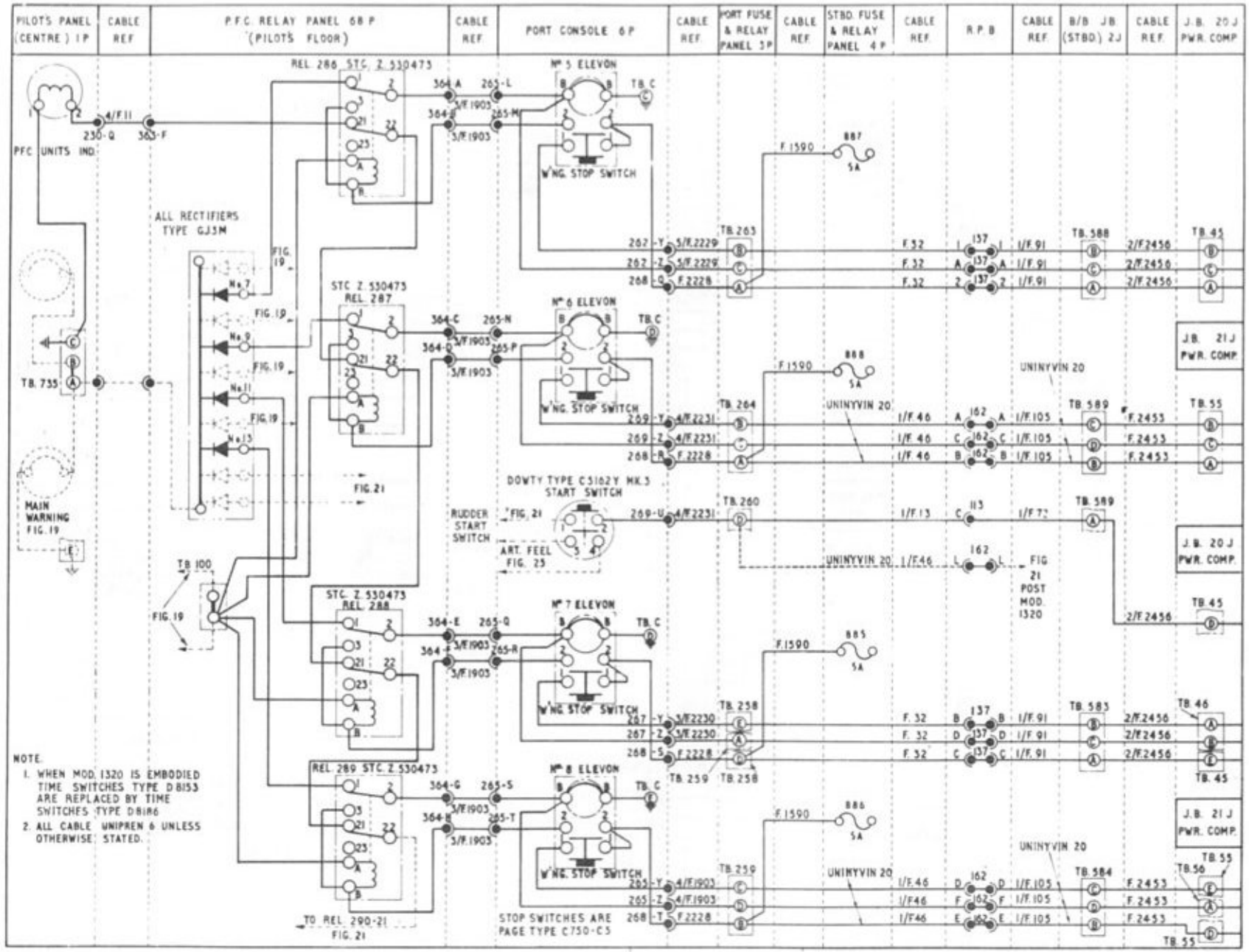



Fig. 20A (1) No. 5,6,7 and 8 elevon P.F.C.'s, (pre and post Mod. 1320, post Mod 2398

◀ Mod 2398 ▶

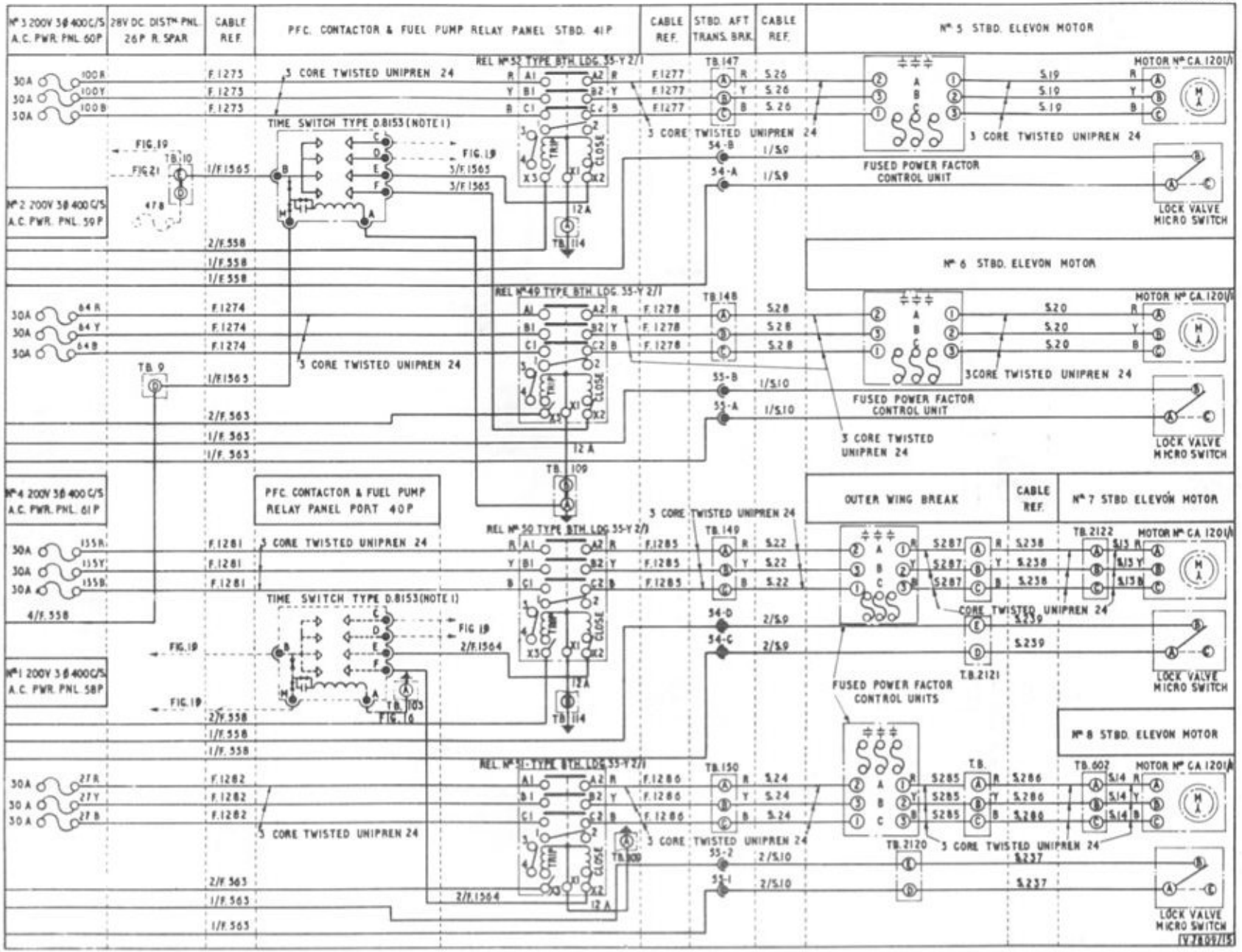



Fig. 20A (2) No. 5, 6, 7 and 8 elevon P.F.C's. (pre and post Mod. 1320, post Mod. 2398)

◀ Mod 2398 ▶

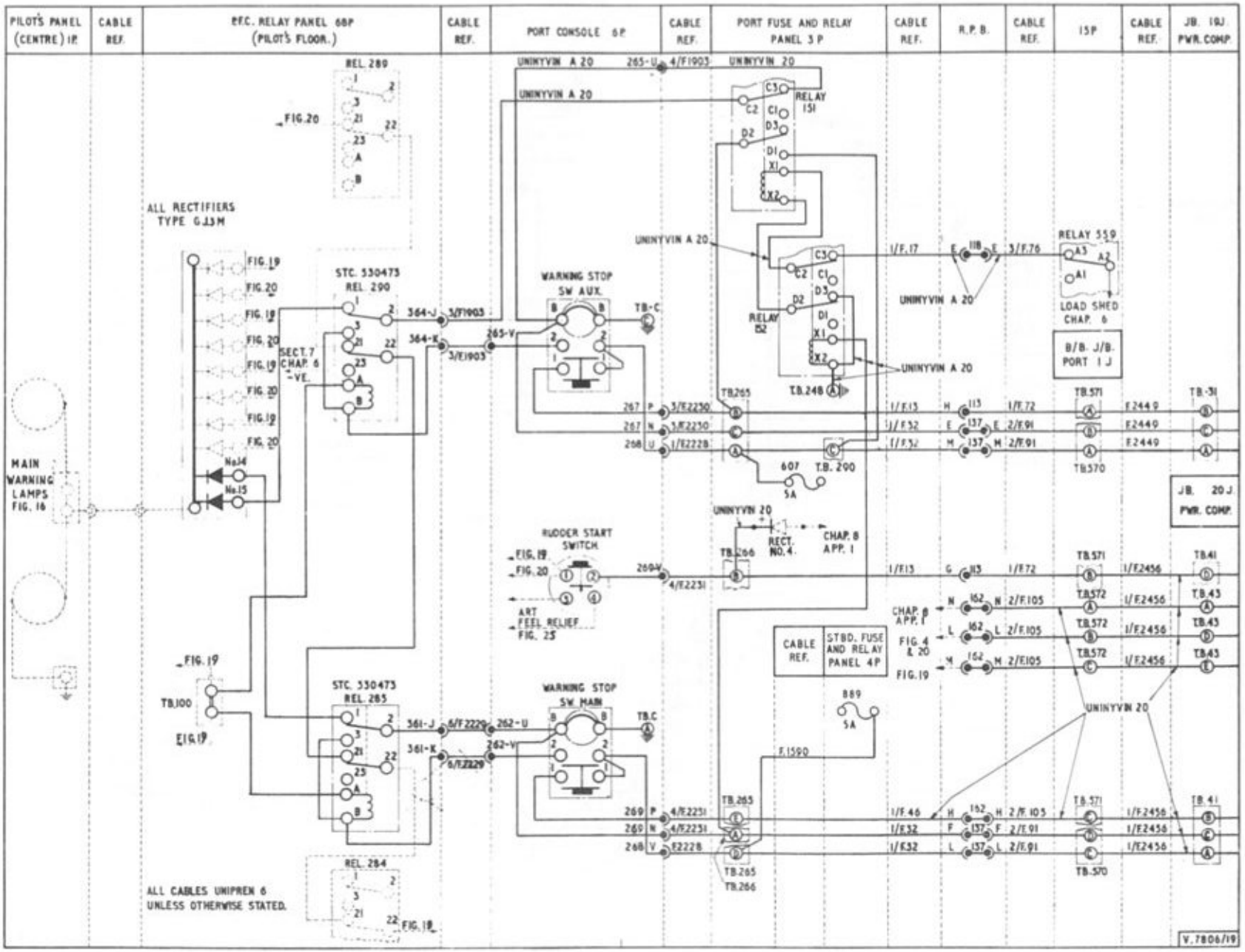



Fig. 21 (1) Rudder P.F.C's. (pre. and post Mod. 1320, pre. Mod. 2398)

*Mod state clarified*

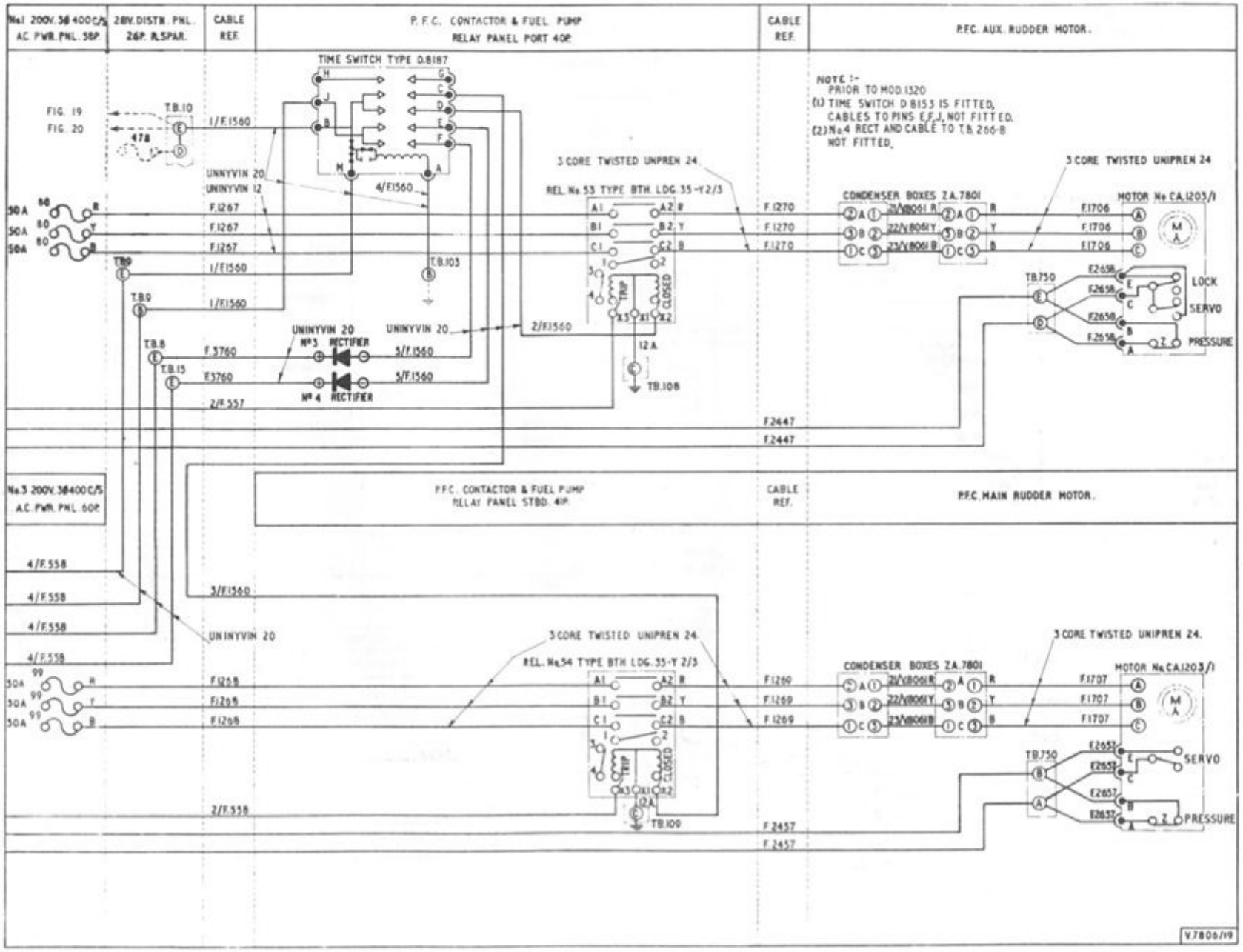



Fig 21 (2) Rudder P.F.C's (pre and post Mod 1320 pre. Mod. 2398)

◀ Mod state clarified ▶

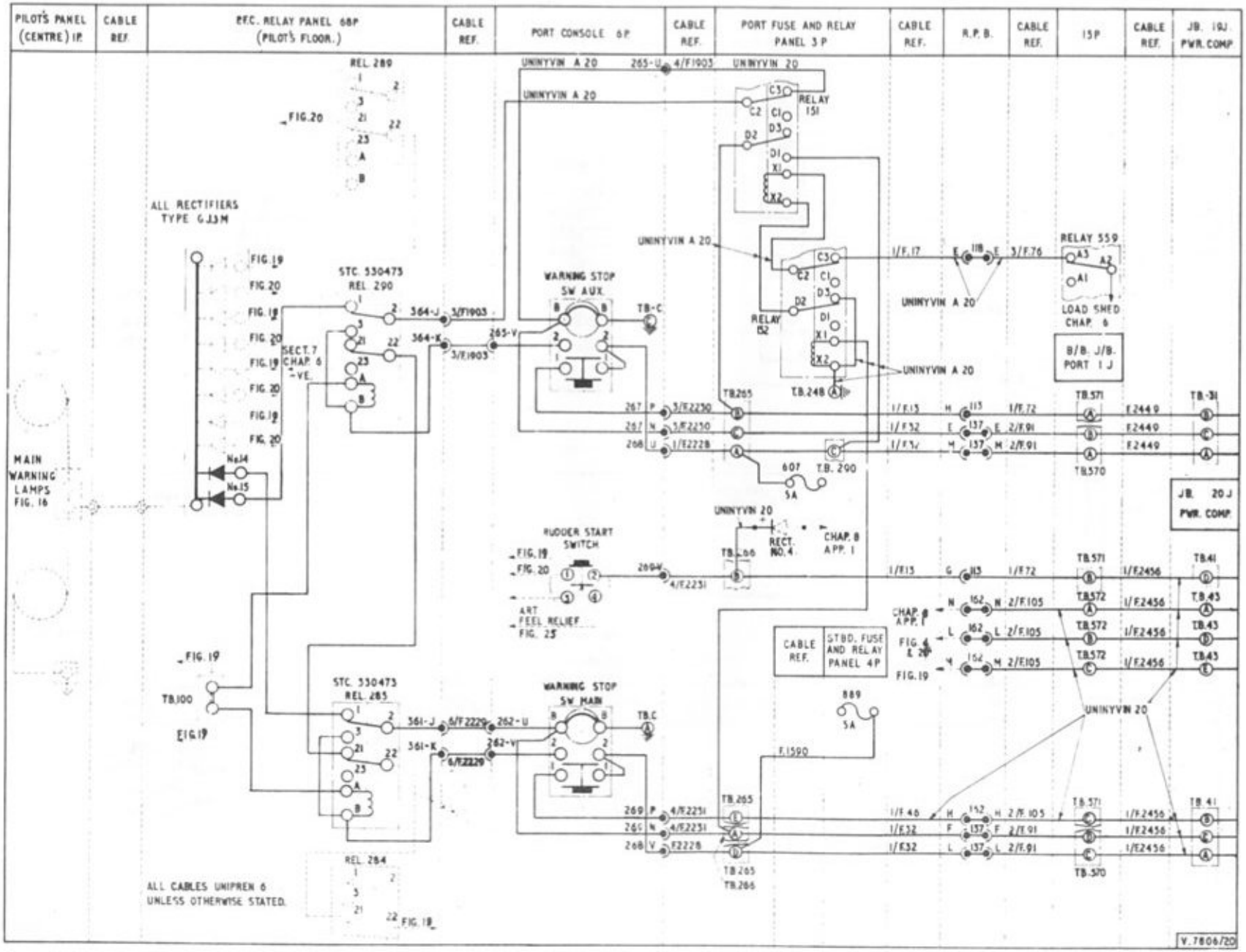



Fig. 21A (1) Rudder P.F.C.'s. (pre and post Mod. 1320, post Mod. 2398.)

◀Mod 2398▶

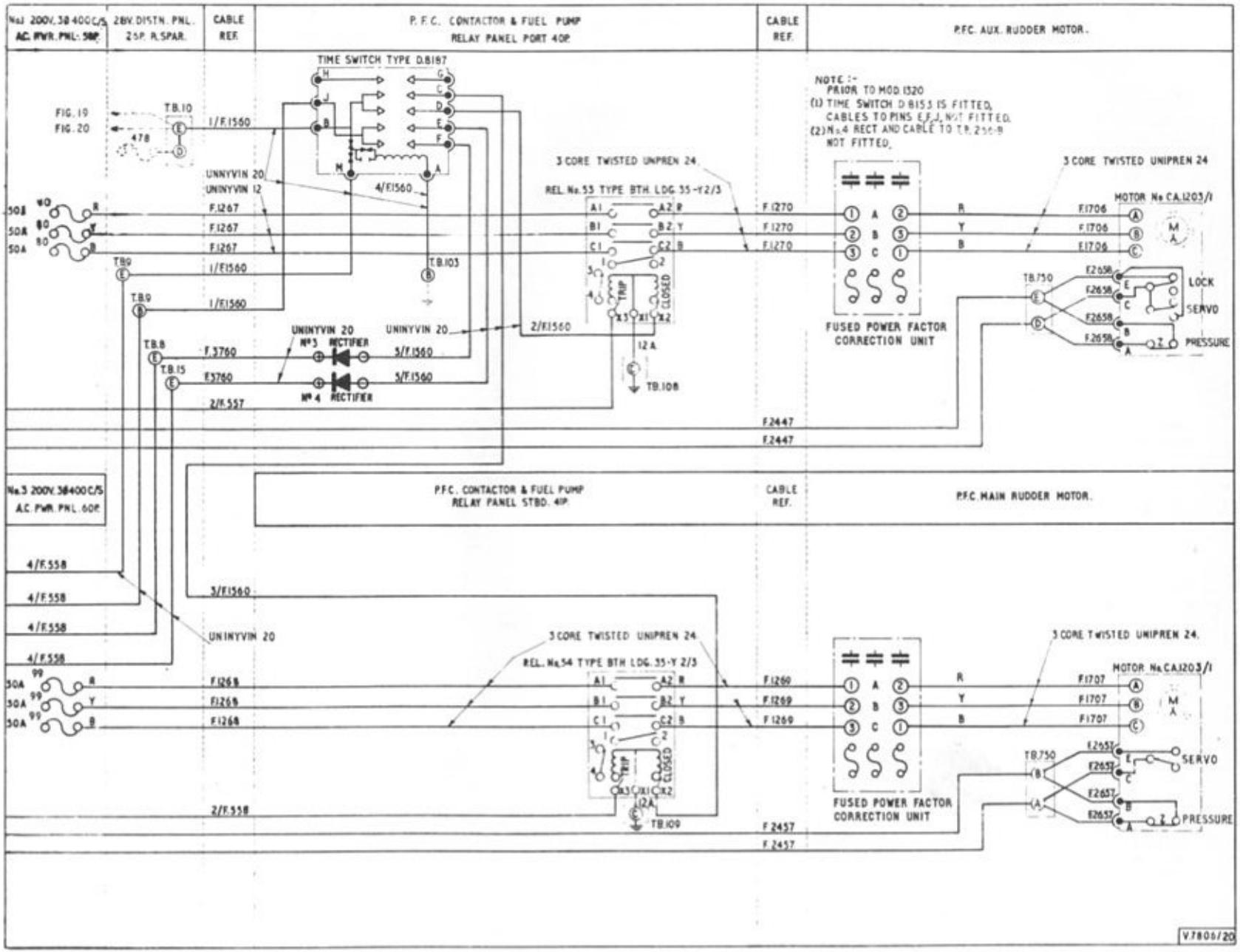



Fig. 21A (2) Rudder P.F.C.'s. (pre and post Mod. 1320, post Mod. 2398)

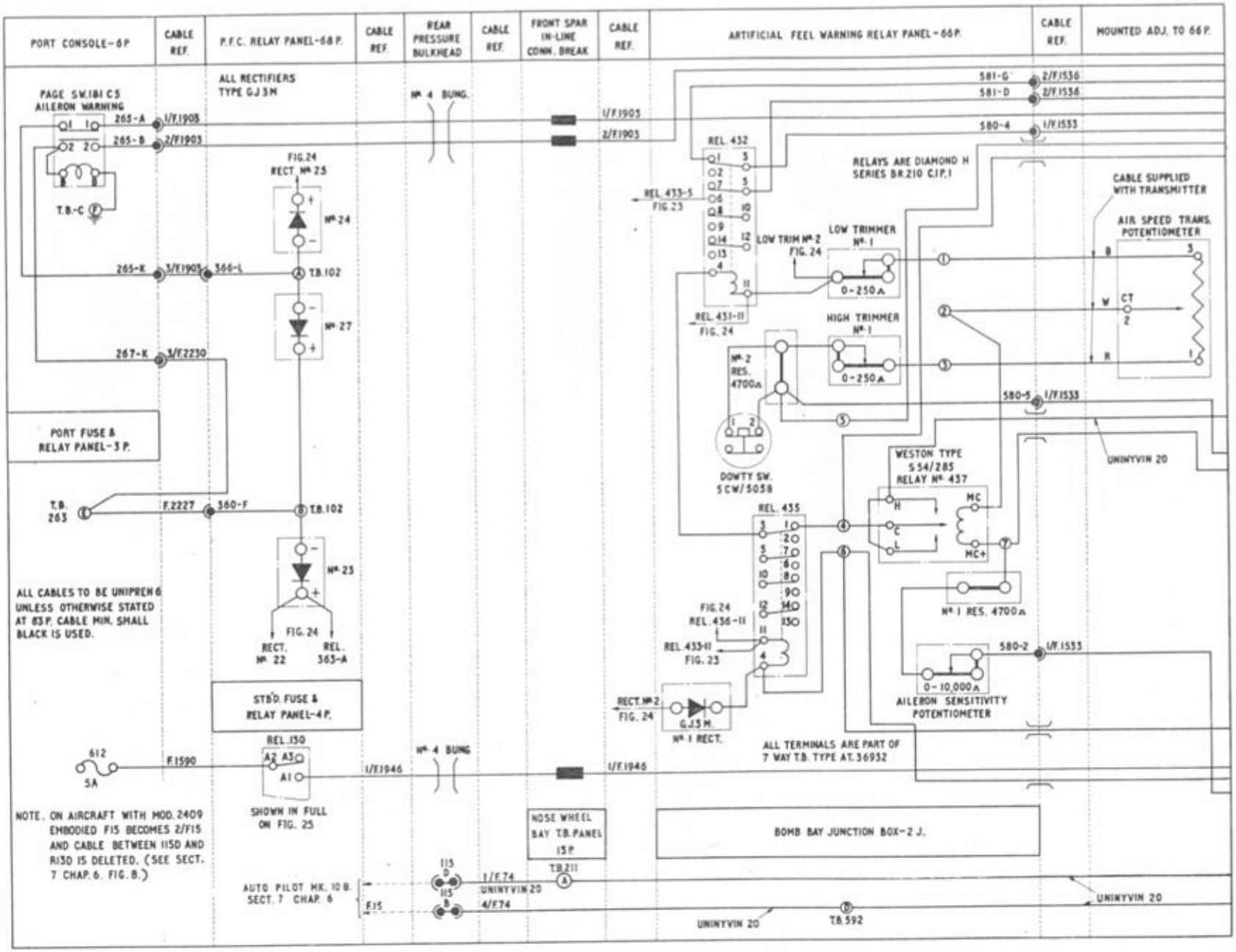



Fig. 22 (1) Artificial feel aileron

▶ *Potentiometer terminal numbers transposed* ◀

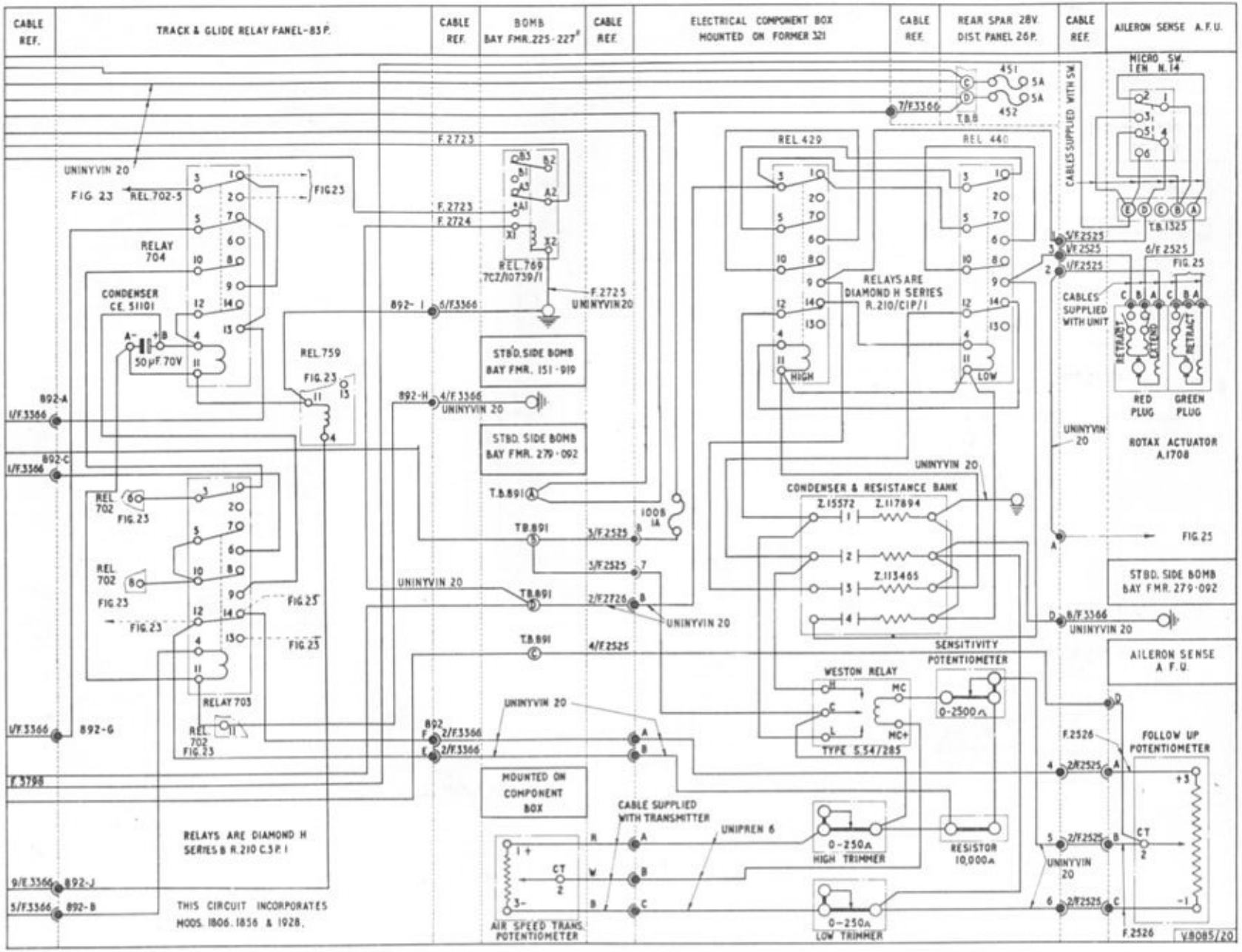



Fig. 22 (2) Artificial feel aileron

▶ *Potentiometer terminal numbers transposed* ◀

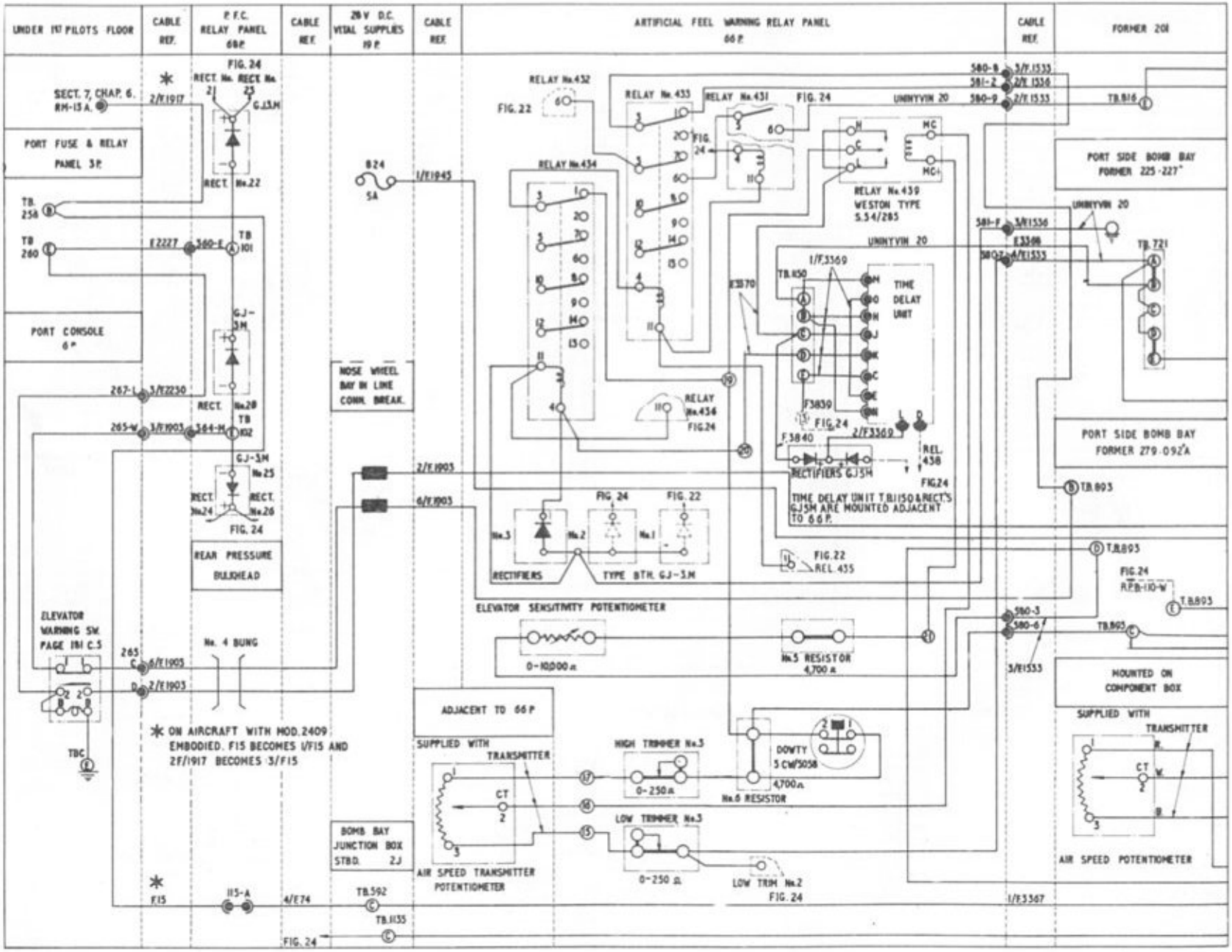



Fig. 23 (1) Artificial feel elevator

▶ *Potentiometer terminal numbers transposed* ◀

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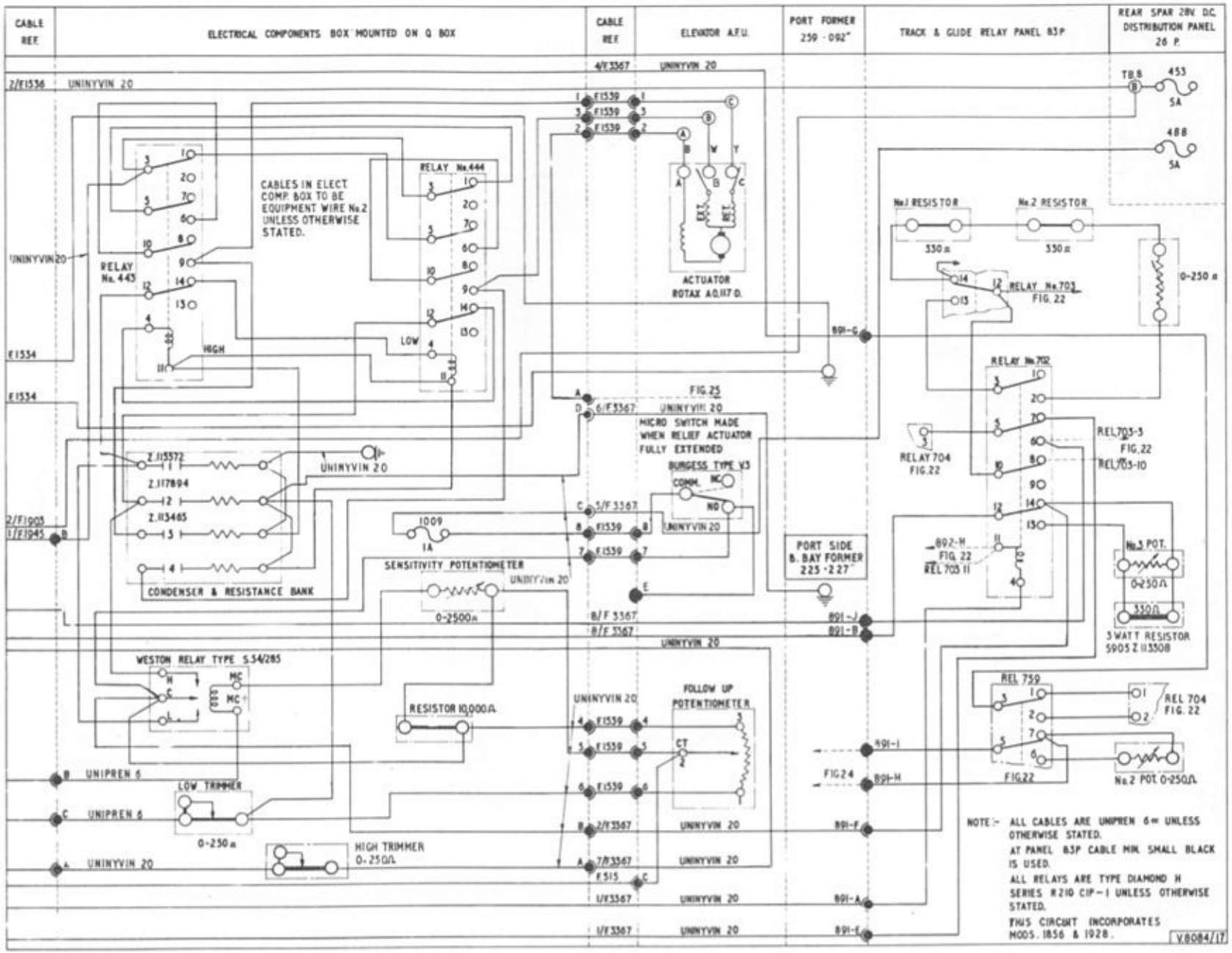


Fig.23 (2) Artificial feel elevator

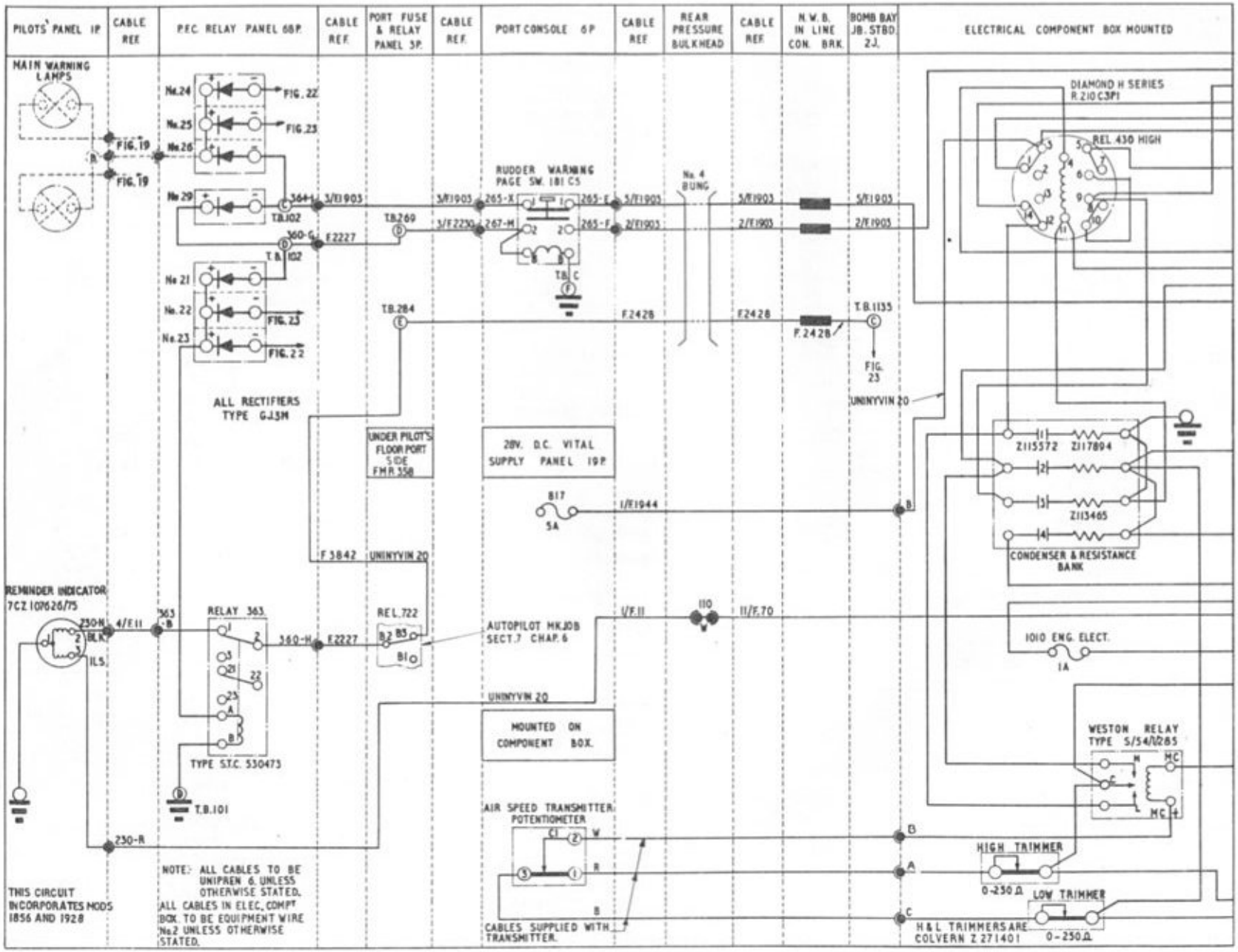


Fig. 24 (1) Artificial feel rudder

*►Potentiometer terminal numbers transposed◄*

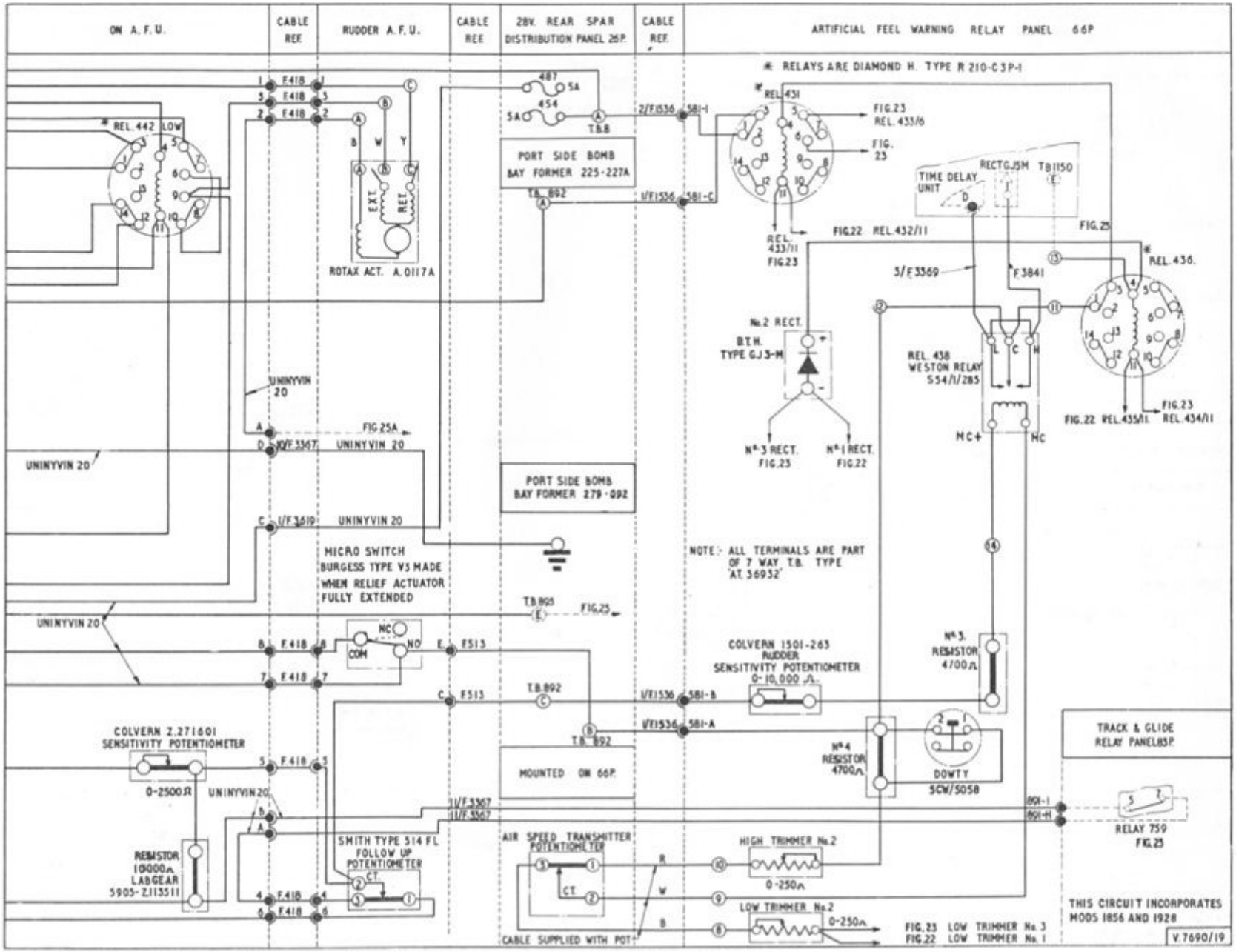


Fig. 24 (2) Artifical feel rudder

► *Potentiometer terminal numbers transposed* ◄

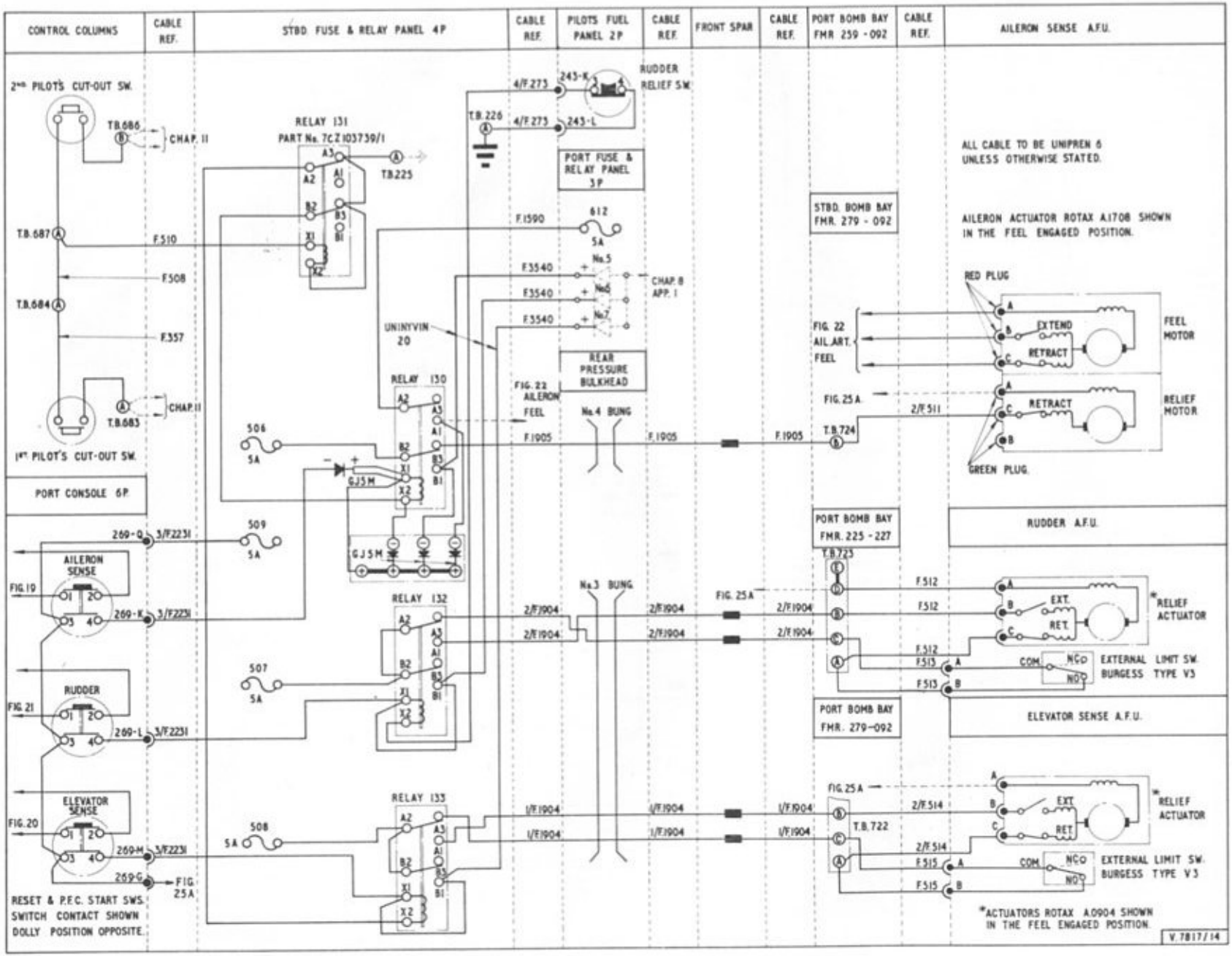


Fig. 25 Artificial feel relief

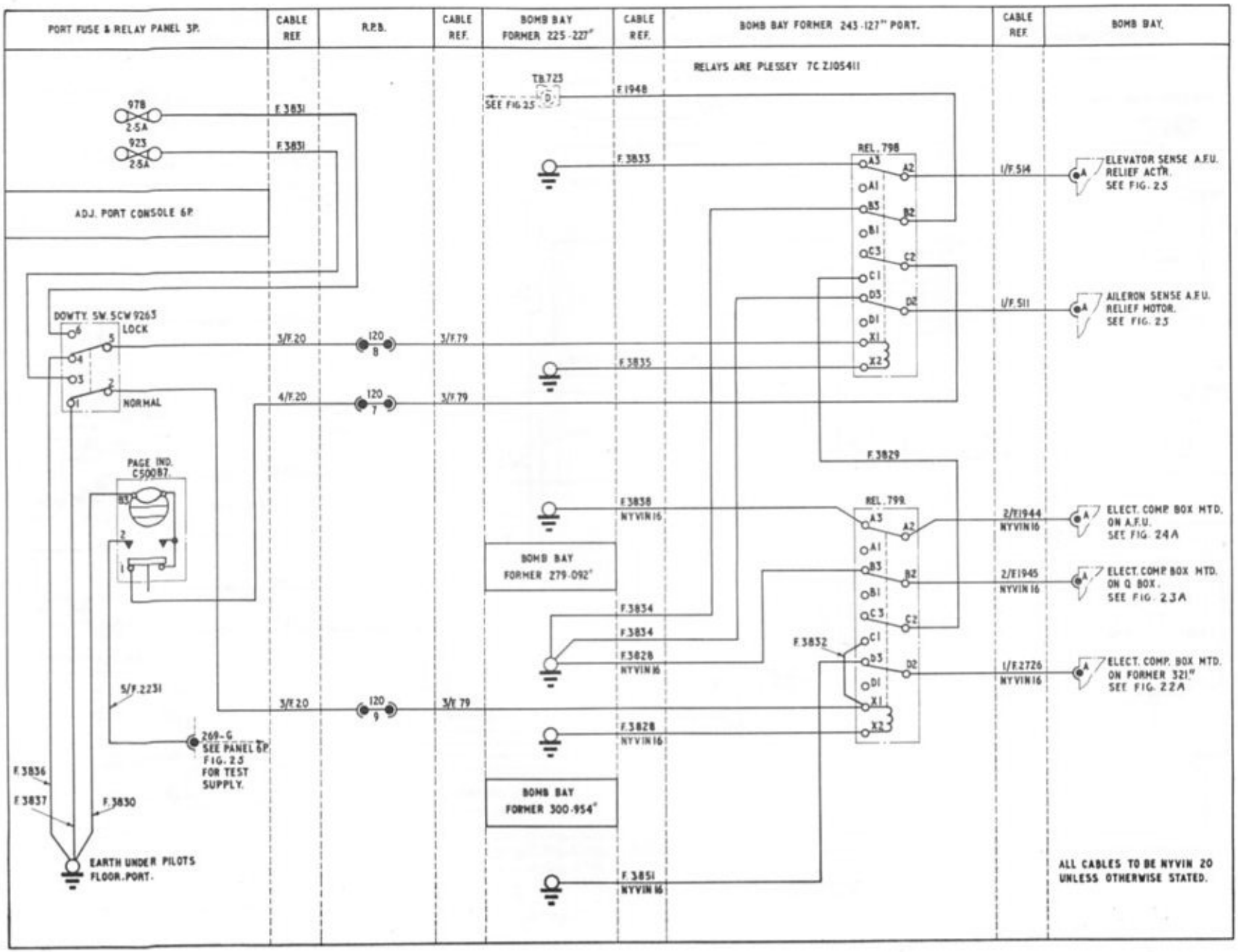


Fig. 25A Artificial feel and feel relief locking.

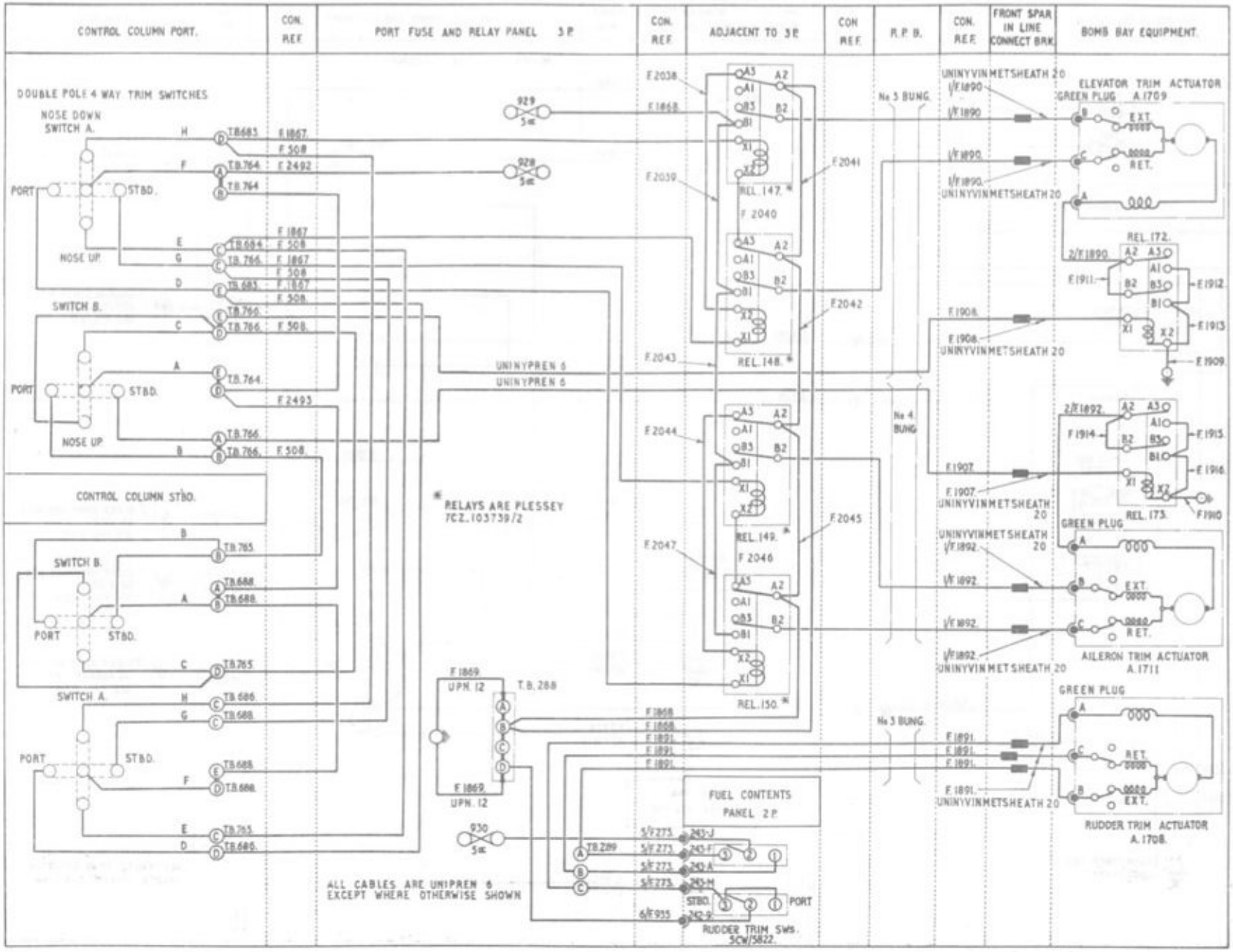


Fig. 26 Normal trim

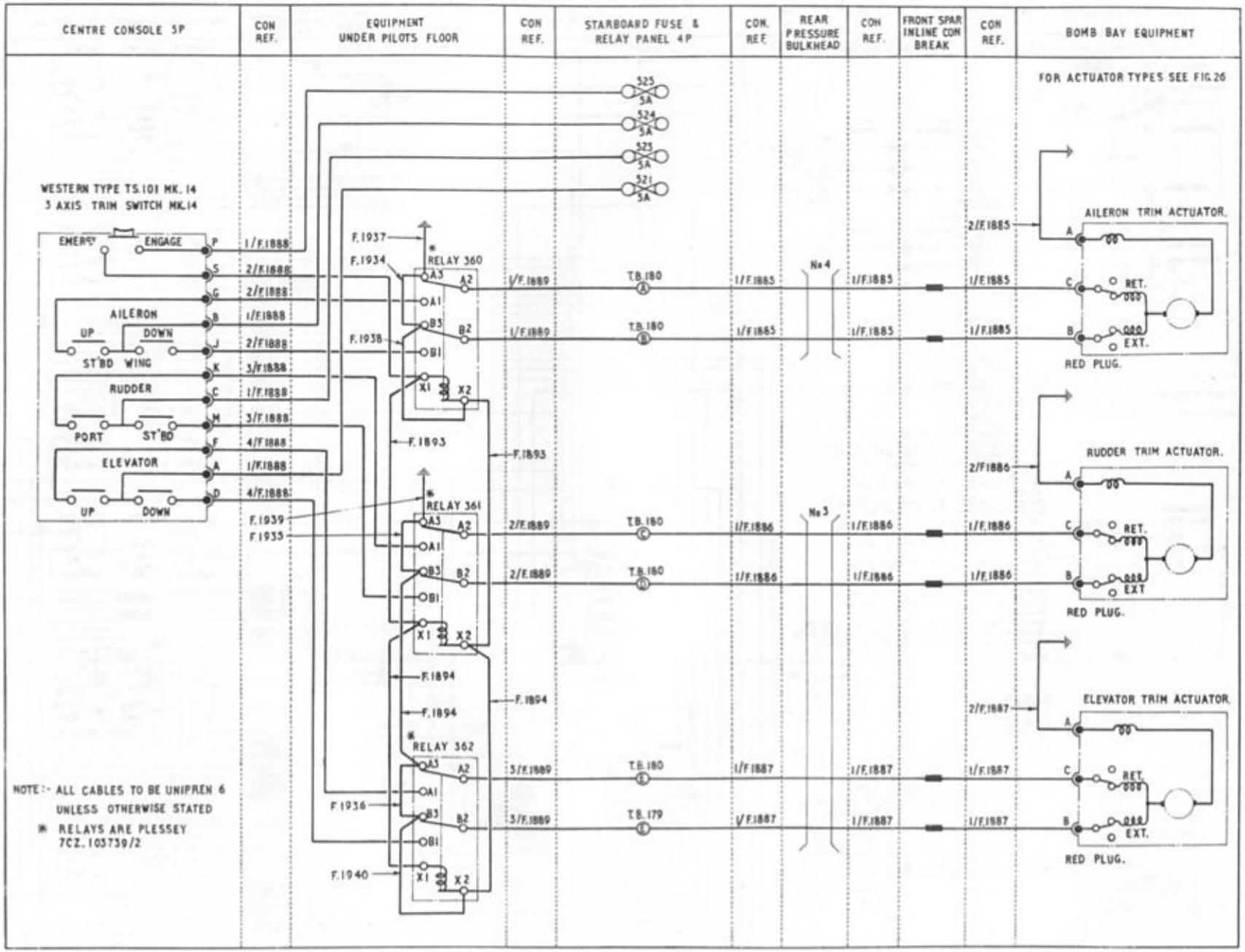


Fig.27 Emergency trim

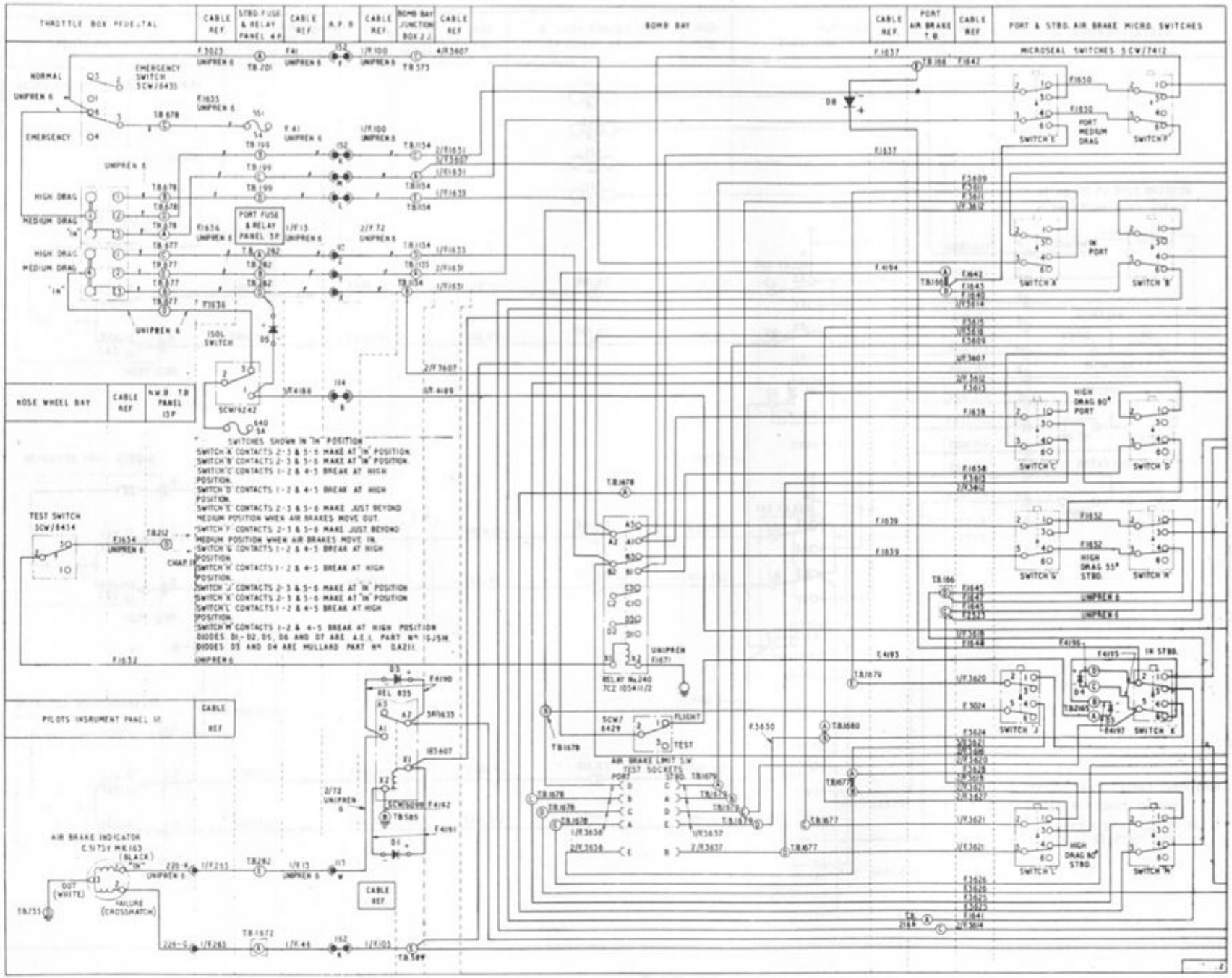


Fig 28 (1) Air brakes (pre Mod 2398)

▶ Mod 2467 ◀

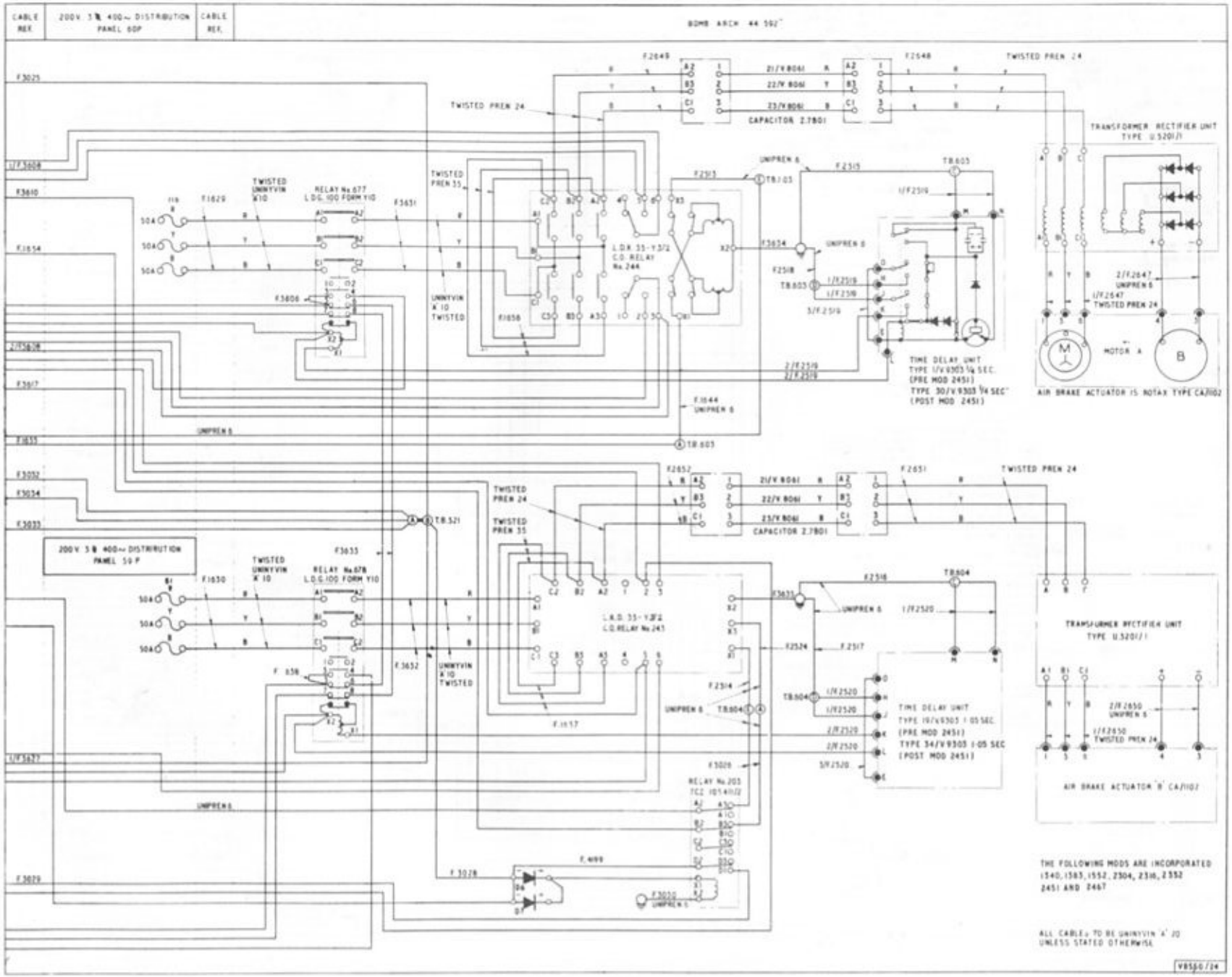


Fig. 28 (2) Air brakes (pre Mod 2398)

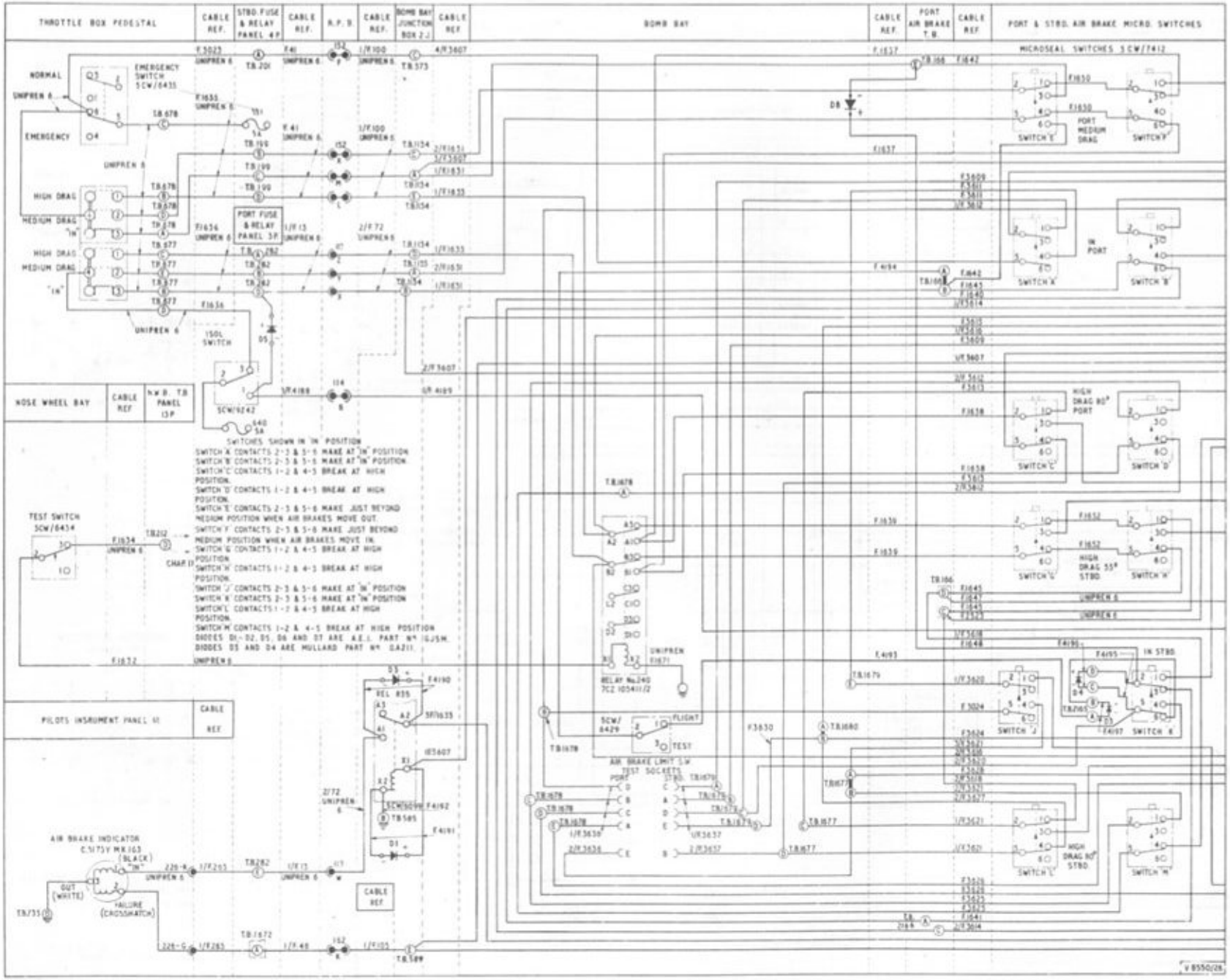


Fig. 29 (1) Air brakes (post Mod 2398)

▶ Mod 2467 ◀

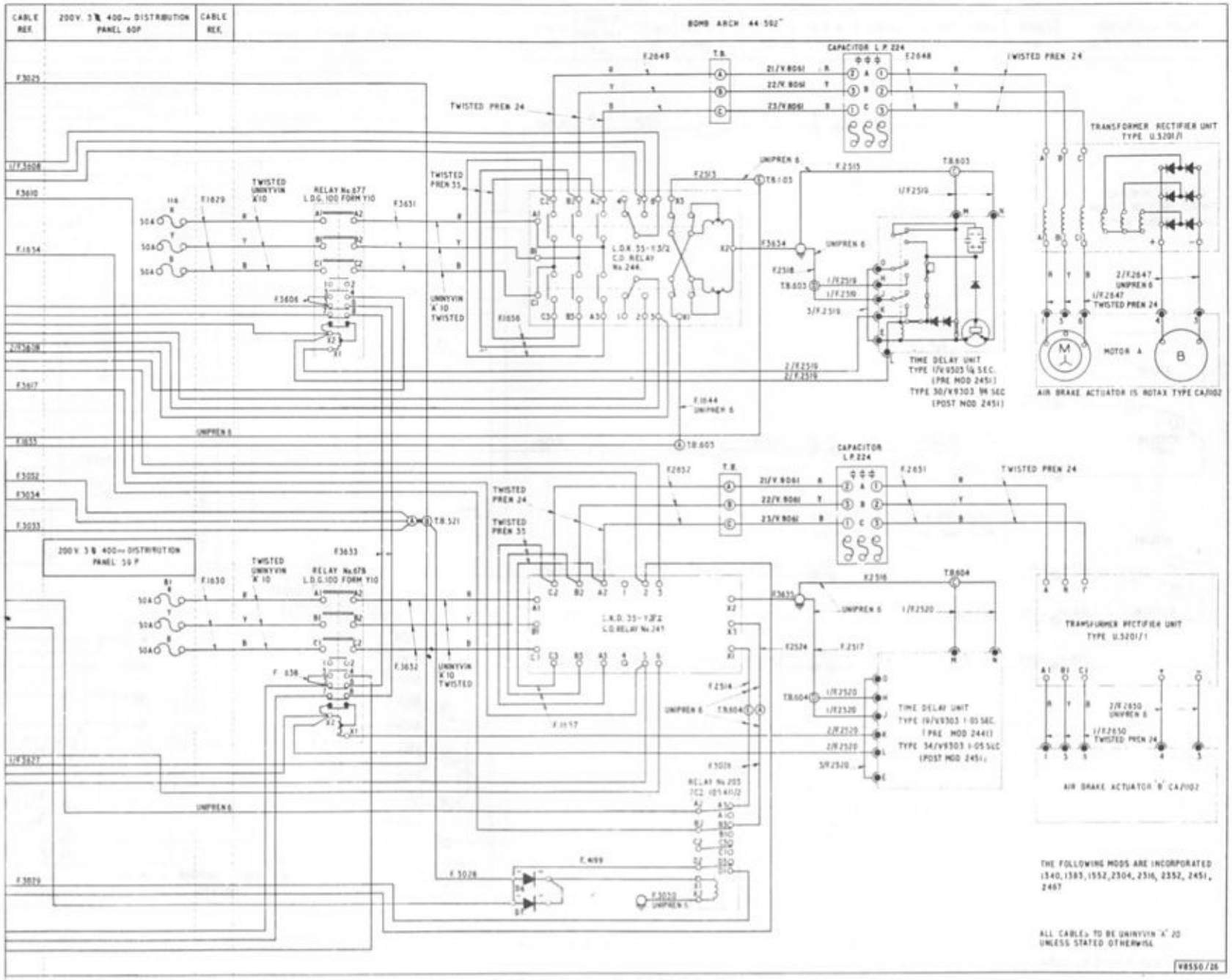


Fig 29 (2) Air brakes (post Mod 2398)
▶ Mod 2451 ◀

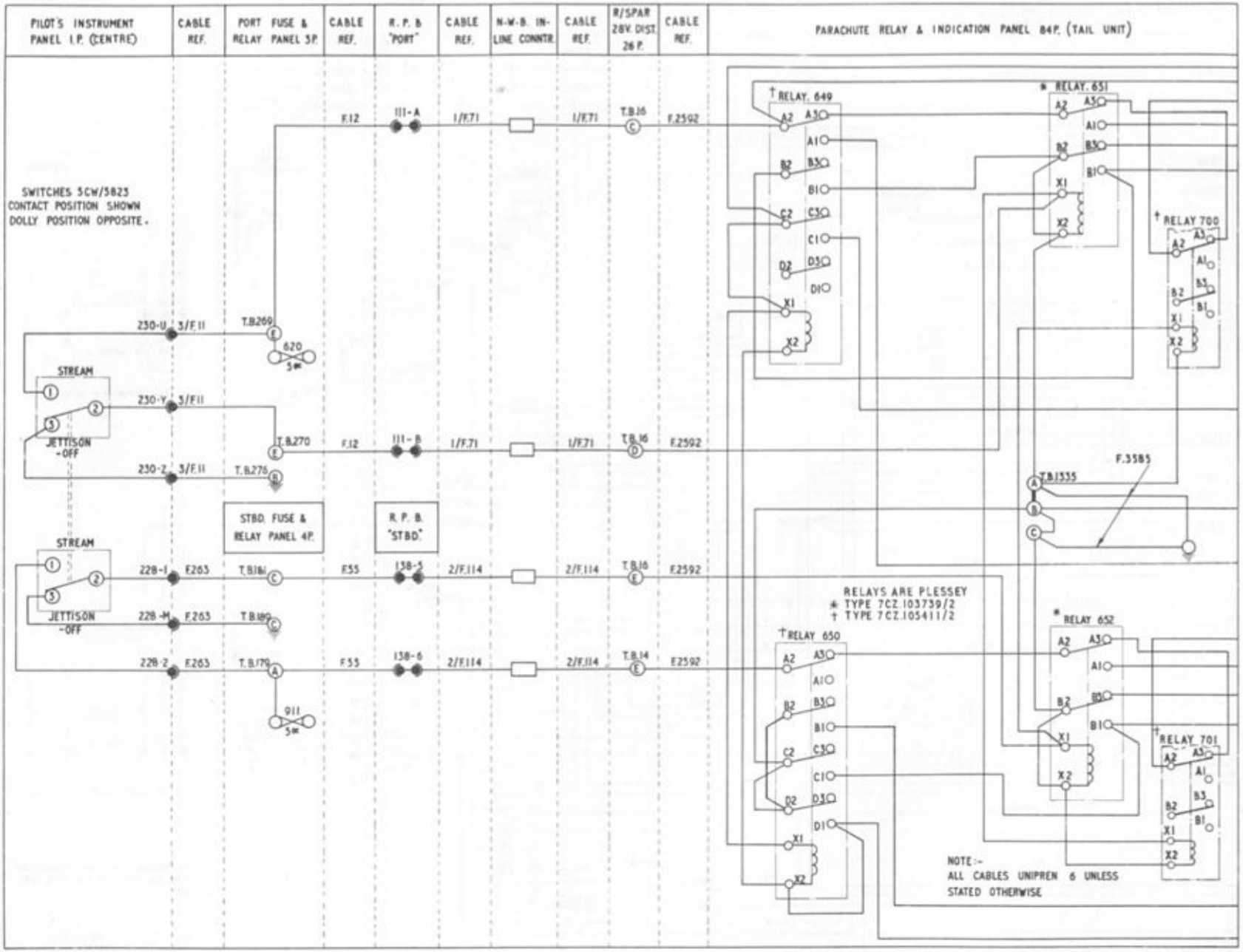


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Fig. 30 (1) Brake parachute

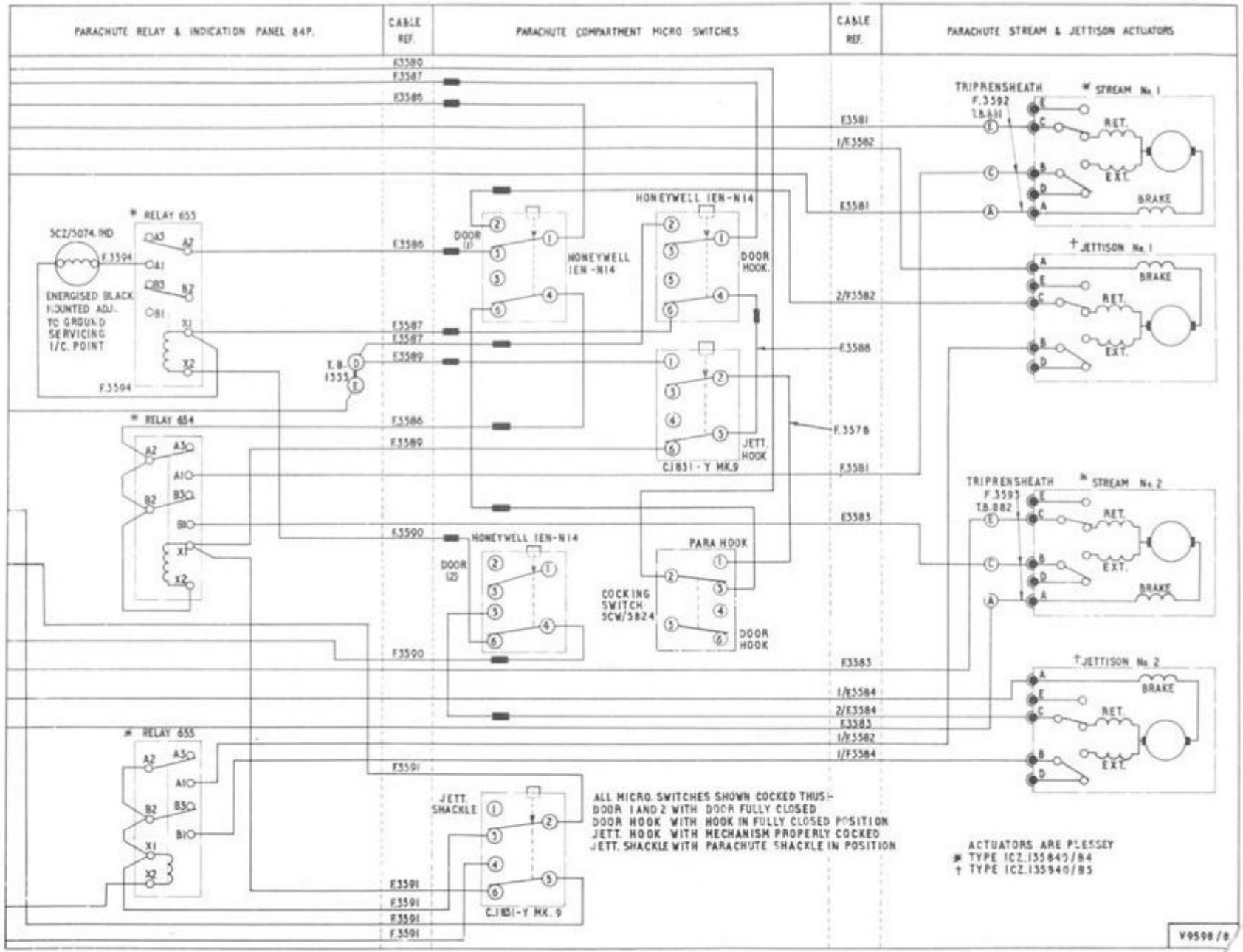


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Fig. 30 (2) Brake parachute

◂Mod 1888▸